KNOWLEDGE
AN ILLUSTRATED
MAGAZINE OF SCIENCE
SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: DECEMBER 2, 1895.

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EDITORIAL NOTE.

WITH the commencement of the New Volume for 1896, KNOWLEDGE will revert to its original Title, "An Illustrated Magazine of Science, Literature and Art," which it bore as founded by Mr. PROCTOR fifteen years ago. The title implies a somewhat extended area of work, and it is hoped that the Magazine will thus afford its readers even greater interest in the future than it has in the past.

With the January Number will be presented the first coloured Astronomical Plate ever issued in KNOWLEDGE. This will take the form of a coloured drawing of the Planet Jupiter, which has been executed by Mr. N. E. GREEN, and reproduced by a special process. The Number will also contain, amongst other Articles, a valuable Paper on "Scientific Geography in England," by Dr. H. R. MILL; and the first of an interesting series of Illustrated Papers on "Waves," by Mr. VAUGHAN CORNISH.

Arrangements have been made for a succession of important Papers in the New Year; comprising a series of articles by Mr. THEO. G. PINCHES on Akkadian and Babylonian Antiquities; Mr. R. LYDEKKER, on Fur-bearing Animals; Mr. H. B. WALTERS, on Greek Art; Mr. J. PENTLAND SMITH, Mr. BOTTING HEMSLEY, and other well-known writers, on Botany; and Mr. G. F. HILL, on English and Italian Medals and Coins.

In Astronomy and Natural Science in all its branches the Magazine will seek to maintain its present excellence; while numerous Articles will be furnished from time to time, both by old contributors and new writers, upon subjects connected with Science, Literature and Art.

THE KRAKATOA ERUPTION.

By Rev. E. RATTENBURY HODGES.

ONE of the fairest regions of the world is the Malay Archipelago. Here Nature is prodigal with her gifts to man. Here the cocoa, palm, cinnamon and other trees flourish, and rice, cotton, the sugar-cane and tobacco yield their increase under cultivation. But, beneath these scenes of loveliness, there are terrific energies, for this region is a focus of intense volcanic action. In it a line of volcanic action is marked by the great vents of Pajung in Java, the cone of Princes Island, Krakatoa, Sebesi and Rajah Bassa in Sumatra, and in the Sunda Straits two such lines of volcanic action would seem to cross each other (Fig. 1). The evidence for this seems to have been furnished by the eruption of Krakatoa in 1883.

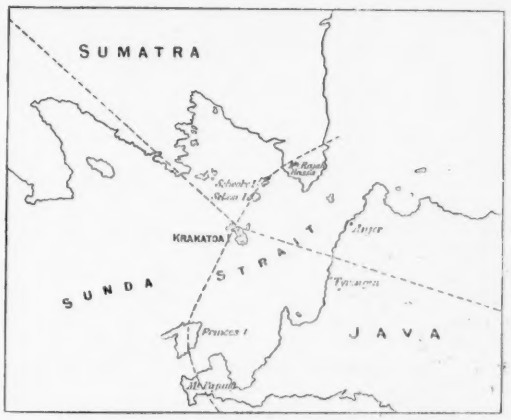


FIG. 1.—Sketch Map, showing the supposed lines of volcanic action.

After providing for the safety and relief of the survivors, the Dutch Government ordered a fresh survey of the Straits, and then resolved upon a scientific investigation of the facts pertaining to this eruption. A commission was appointed in October, 1883, and Dr. Verbeek, already well known as an experienced scientific surveyor of those regions, was able to give his valuable services. The report of their proceedings appeared in February, 1884. At about this time, the French Government sent out two investigators to the region, and their observations were subsequently published.

In January, 1884, the Council of the Royal Society appointed a committee to collect and scientifically investigate as far as possible all data relating to the eruption. The issue of their labours was a report,* published in 1888. To this work we are largely indebted for the materials of the present article, and also for the accompanying illustrations, which have been copied by kind permission of the Royal Society.

In the Sunda Straits there lies a group of small volcanic islands (Fig. 2). The largest of these is Krakatoa. It forms part of the "basal wreck" of a large submarine volcano, whose visible edges are also represented by Verlaten and Lang Islands. In the Greek Archipelago there is a similar example in the islands of Thera and Therasia.

* A work of 500 pages, quarto, with maps, plates, and charts. The pages relating to the bibliography of the subject are also of much value.

These are regarded as parts of the rim of the great crater-

Fig. 2.—Chart prepared *after* the Eruption. The shaded portions show the islands according to the old chart.

basin of Santorin. The dotted line on the map of Krakatoa (Fig. 3) is an ideal completion of the circuit of this volcanic stump, the whole representing a circumference of about twenty-five miles. Its underlying rocks indicate its probable existence in Pleistocene times.

Within the circle referred to we have set two thick little rings. They represent two points of eruption, presently to be referred to, *i.e.*, Perboewatan, at the north end, and Danan near the middle of Krakatoa Island.

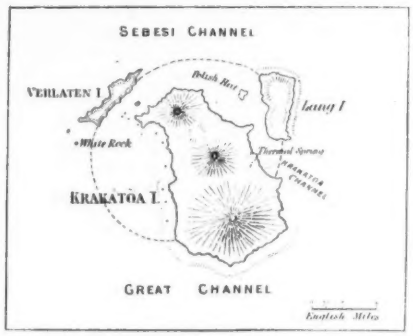


Fig. 3.—Map of the Krakatoa Group, before the Eruption. The dotted line indicates, approximately, the submerged edge of the Great Crater.

For two hundred years the igneous forces beneath Krakatoa remained dormant. In September, 1880, premonitory shocks of earthquake were felt in the neighbourhood. At length the inhabitants of Batavia and Buitenzorg were startled on May 20th, 1883, by booming sounds which came from Krakatoa, one hundred miles distant. A mail steamer passing through the Strait, had her compass violently agitated. Next day a sprinkling of ashes was noticed at some places on each side of the Strait, but towards evening a steam-column rising from Krakatoa revealed the locality of disturbance. The commander of the German war-ship *Elisabeth*, while passing, estimated the dust-column to be about thirty-six thousand feet, or seven miles high.

Volcanic phenomena being common to that region, no fears were entertained by the inhabitants in the vicinity. An excursion party even started from Batavia to visit the scene of action. They reached the island on May 27th and saw that the cone of Perboewatan was active, and that a column of vapour rose from it to a height of less than ten thousand feet, while lumps of pumice were shot up to about six hundred feet. Explosions occurred at intervals of from five to ten minutes, each of these outbursts uncovering the liquid lava in the vent, the glow of which lighted up the overhanging steam-cloud for a few seconds.

Shortly after this visit the activity diminished. But on June 19th it was noticed at Anjer that the height of the dust and vapour-column, and likewise the explosions, were again increasing. On the 24th a second column was seen rising. At length, Captain Ferzenaar, chief of the Topographical Survey of Bantam, visited Krakatoa Island on August 11th. He found its forests destroyed, and a mantle of dust near its shores was twenty inches thick. Three large vapour-columns were noted, one marking the position of the crater of Perboewatan, while the other two were in the centre of the island, and, of the latter, one was probably Danan. There were also no fewer than eleven other eruptive foci, from which issued smaller steam-columns and dust. This was the last report prior to the great paroxysm. During the next two or three weeks there was a decline in the energy of the volcano, but on the afternoon of Sunday, August 26th, and all through the following night, it was evident that the period of moderate eruptive action had passed, and that Krakatoa had now entered upon the paroxysmal stage. "From sunset on Sunday till midnight, the tremendous detonations followed each other so quickly that a continuous roar may be said to have issued from the island." The full terrors of the eruption were now approaching. The distance of ninety-six miles from Krakatoa was not sufficient to permit sleep to the inhabitants of Batavia. "All night volcanic thunders sounded like the discharges of artillery at their very doors." On the next morning there were four mighty explosions, *i.e.*, at 5.30, 6.44, 10.2, and 10.52 (Krakatoa time). The third, *i.e.*, at 10.2, was of appalling violence, and it gave rise to the most far-reaching effects. The entire series of grand phenomena at that spot extended over a little more than thirty-six hours.*

Captain Thomson, of the *Medea*, then seventy-six miles E.N.E. of Krakatoa, saw a black mass like smoke rising into the clouds to an altitude estimated at not less than seventeen miles. The eruption was also viewed by Captain Wooldridge at a distance of forty miles. He speaks of the vapory mass looking like "an immense wall, with bursts of forked lightning, at times like large serpents rushing through the air." After sunset this dark wall resembled "a blood-red curtain with the edges of all shades of yellow, the whole of a murky tinge, with fierce flashes of lightning." Two other masters of vessels, at about the same distance from the volcano, report seeing the mast-heads and yardarms of their ships aglow with electric fire. Such effects seem to be easily explicable. When we consider how enormous must be the friction going on in the hot air, through the clash against each other of myriads of particles of volcanic dust, during ejection and in their descent, it is evident that such friction is adequate to produce a wide-spread electrical disturbance in the sur-

* It ceased at about 2.30 a.m. on Tuesday, August 28th.

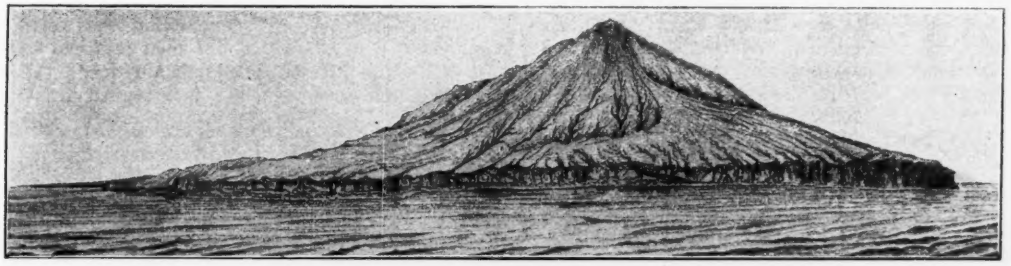
rounding atmosphere. The rush of steam through craters or other fissures would also contribute to these disturbances.

From these causes also the compasses of passing ships were much disturbed. And yet the fall of magnetic oxide of iron (magnetite), a constituent of volcanic ash, possibly had some share in creating these perturbations. On the telephone line from Ishore, which included a submarine cable about a mile long, reports like pistol shots were heard. At Singapore, five hundred miles from Krakatoa, it was noted at the Oriental Telephone Company's station that, on putting the receiver to the ear, a roar like that of a waterfall was heard. So great was the mass of vapour and dust in the air that profound darkness, which lasted many hours, extended even to one hundred and fifty miles from the focus of eruption. There is the record, among others, that it was "pitch dark" at Anjer at 2 p.m. on the 26th.

So great, too, was the ejective force that, according to Dr. Verbeek's estimate, the fine volcanic dust was blown up to a height of fifty thousand feet, or over nine miles, into space. Another estimate gives, as before stated, the enormous altitude of seventeen miles to which the dust had been blown. The volcanic ash, which fell upon the neighbouring islands within a circle of nine and a half miles radius, was from sixty-five to one hundred and thirty feet thick. At the back of the island the thickness of the ash-beds is from one hundred and ninety-five to two hundred and sixty feet. Masses of floating pumice cumbered the Strait. The coarser particles of this ash fell over a known area equal to two hundred and eight-five thousand one hundred and seventy square miles—a space equal to the whole of the German Empire, Holland, Belgium, Denmark and Iceland. It has been calculated that the matter so ejected must have been considerably over a *cubic mile in volume*.

consciences, for, being guilty of murder, they fled, fearing that such sounds signified the approach of an avenging force. Again, in the island of Timor, one thousand three hundred and fifty-one miles away, the people were so alarmed that the Government sent off a steamer to seek the cause of the disturbance. At that time also, the shepherds on the Victoria plains, West Australia, thought they heard the firing of heavy artillery, at a spot one thousand seven hundred miles distant. At midnight, August 26th, the people of Daly Waters, South Australia, were aroused by what they thought was the blasting of a rock, a sound which lasted a few minutes. "The time and other circumstances show that here again was Krakatoa heard, this time at the enormous distance of two thousand and twenty-three miles." And yet there is trustworthy evidence that the sounds were heard over even greater distances. Thundering noises were heard at Diego Garcia, in the Chagos Island, two thousand two hundred and sixty-seven miles from Krakatoa. It was imagined that some vessel must be in distress, and search was accordingly made. But most remarkable of all, Mr. James Wallis, chief of police in Rodriguez, across the Indian Ocean, and nearly three thousand miles away from Krakatoa, made the following statement, that "several times during the night of August 26th–27th reports were heard coming from the eastward like the distant roar of heavy guns. These reports continued at intervals of between three and four hours." Obviously, some time was needed for the sounds to make such a journey. On the basis of the known rate of velocity, they must have been heard at Rodriguez four hours after they started from their source.*

And yet, great as was the range of such vibrations, they could not be compared with that of the air-wave caused by the mighty outburst. This atmospheric wave started from Krakatoa at two minutes past ten on that eventful Monday morning, moving onward in an ever-



Krakatoa, after the Eruption, as seen from the south-east.

Another distinguishing feature of this display of Nature's powers was the magnitude and range of the explosive sounds. It has been well remarked by Sir Robert Ball that were Vesuvius so to act, everyone in Great Britain would be near enough to hear the awful detonations. Lloyd's agent at Batavia, ninety-four miles distant from Krakatoa, reported that on the morning of the 27th the reports and concussions were simply deafening. At Carimon, Java Island, which is three hundred and fifty-five miles distant, the natives heard reports which led them to suppose that a distant ship was in distress; boats put off for what proved to be a futile search. The explosions were heard not only all over the province of Macassar, nine hundred and sixty-nine miles from the scene of the eruption, but over a yet wider area. At a spot one thousand one hundred and sixteen miles distant—St. Lucia Bay, Borneo—some natives heard the awful sound. It stirred their

widening circle, like that produced when a stone is thrown into smooth water. This ring-like wave travelled on at the rate of from six hundred and seventy-four to seven hundred and twenty-six miles an hour, and went round the world four, if not even seven times, as evidenced by the following facts. Batavia is nearly a hundred miles from the eruptive focus under review. There was connected with its gasholder, the usual pressure recorder. About thirteen minutes after the great outburst, this gauge showed a barometric disturbance equal to about four-tenths of an inch of mercury, *i.e.*, an extra air-pressure of about a fifth of a pound on every square inch. The effects on the air of minor paroxysmal outbreaks are also recorded by this instrument; but barometers in the most distant places

* Later on, it was stated that booming sounds were heard on that day at Caiman Brac, in the West Indies, the *antipodes* of Krakatoa.

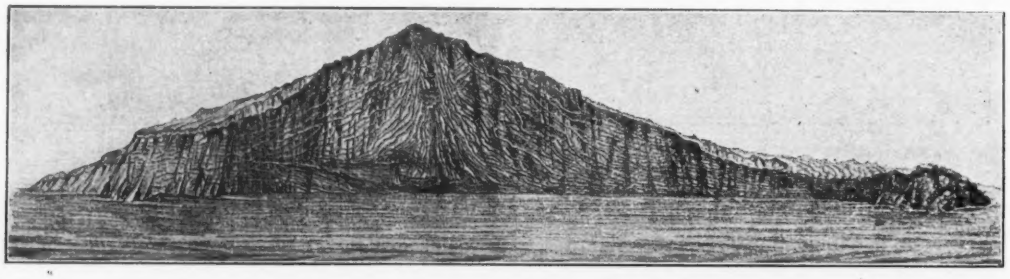
record the same disturbance. "The great wave passed and repassed again over London, and no inhabitant was conscious of the fact." The barometer at Greenwich Observatory automatically recorded this effect; moreover, the instruments at Kew confirm those at Greenwich. Evidence of the same kind was also obtained from Valentia (Ireland), Paris, St. Petersburg, Berlin, Palermo, Rome, New York, Toronto, Mauritius, Tokio, Bombay, Melbourne, and many other places. "All the instruments record the first great wave from Krakatoa to its antipodes in Central America, and also the return wave." The first four oscillations left their mark on upwards of forty barograms, the fifth and sixth on several, and at Kew the existence of a seventh was certainly established.

At the same time that this immense aërial undulation started on a tour round the world, another wave, but of awful destructiveness, *i.e.*, a seismic sea-wave, started on a similar journey.* There can hardly be a doubt that this so-called "tidal wave" was synchronous with the greatest of the explosions. A wave from fifty to seventy-two feet high arose, and swept with resistless fury upon the shores each side of the Straits. The destruction to life and property will probably never be fully known. At least thirty-six thousand three hundred and eighty lives were lost, and a great part of the district of North Bantam was destroyed, and the towns of Anjer, Merak, Tyringin, and neighbouring villages were overwhelmed.† A man-of-war, the *Beroux*, was cast upon the shore of Sumatra one mile and three-quarters inland, and masses of coral, from twenty to fifty tons in weight, were torn from the sea-bed and swept upon the shore. Following this seismic sea-wave, the waters of the Strait ebbed and flowed sixteen times in three hours. The cause of this immense wave is, of course, conjectural. Large masses of the island were probably blown away by the force of the explosion, and falling into the sea propagated the wave, or possibly the sudden displacement of water over a submarine vent gave rise to such an undulation. It is stated on high authority that the missing mass of Krakatoa equals two hundred thousand million cubic feet, and that a fiftieth part of this mass dropped suddenly into the sea would create displacement sufficient to make a circle-wave nearly one hundred miles in circumference, twenty feet high and three hundred and fifty feet wide.

The captain of the *Charles Ball*, who was afloat a few miles to the north of Anjer, and his helmsman "saw a wave rush right on to Button Island, apparently sweeping right over the south part and rising half-way up to the north and east sides, fifty or sixty feet, and then continuing on to the Java shore." He then adds the valuable remark, "this was evidently a wave of translation and not of progression, for it was not felt at the ship." This movement coincided with the great "tidal wave," so called, which was felt on the Ceylon coast, Aden, Port Blair, Nagapatam, Port Elizabeth, Kurrachee, Bombay, and half-way up to Calcutta on the Hooghly, the north-east coast of Australia, at Honolulu (Sandwich Islands), Kadiall in Alaska, San Celeto near San Francisco, and Table Bay.

A few days after this eruption some remarkable sky-effects were observed in different parts of the world. Many of these effects were of extraordinary beauty. Accordingly, scientific inquiry was made, and in due time there was collected and tabulated a list of places from whence these effects were seen, together with the dates of such occurrences. Eventually it was concluded that such optical phenomena had a common cause, and that it must be dust of ultra-microscopic fineness at an enormous altitude. All the facts indicated that such a cloud started from the Sunda Straits, and that the prodigious force of the Krakatoa eruption could at that time alone account for the presence of impalpable matter at such a height in the atmosphere. This cloud travelled at about double the speed of an express train by way of the tropics of Cancer and of Capricorn. Carried by westerly-going winds, in three days it had crossed the Indian Ocean and was rapidly moving over Central Africa; two days later it was flying over the Atlantic; then, for two more days, over Brazil, and then across the Pacific towards its birthplace. Its course has been thus happily phrased by Sir Robert Ball:—"The dust of Krakatoa had put a girdle round the earth in thirteen days." But the wind still carried this haze of fine particles, now spread out over a wider track, onward, and again it went round the world within a fortnight. In November, the dust area had expanded so as to include Europe and North America.

Here are a few of the facts culled from the Royal Society Report. On the 28th, at Seychelles, the sun was seen as through a fog at sunset, and there was a lurid glare all over the sky after sunset. At the island of Rodriguez, on that day, "a strange red threatening sky at sunset" was seen. At Mauritius (28th), there is the record "crimson dawn, sun red after rising, gorgeous sunset, first of the afterglows; sky and clouds yellow and red up to the zenith." 28th and 29th, Natal—"most vivid sunsets, also August 31st and September 5th, sky vivid red, fading into green and purple." On the last days of August and September 1st the sun, as seen from South



Krakatoa, after the Eruption, as seen from the north.

* The sea disturbance was probably composed of two descriptions of waves—long waves, with periods of over an hour, and shorter but higher waves, with irregular and much briefer intervals. The great disturbance was probably formed of both descriptions of waves, originated at Krakatoa at about ten a.m.—*Roy. Soc. Report.*

† At Tyringin (twenty-four miles from Krakatoa), as the people on the hills at the back of the plain, stated to be sixty-seven to one hundred feet high, were saved, it does not appear that the wave could have been much over seventy feet.—*Roy. Soc. Report.*

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THE GOLDEN EAGLE'S EYRIE, WITH YOUNG AND PREY.

By permission of Mr. W. Green, of Berwick.

THE GOLDEN EAGLE'S NEST.

By permission of Mr. W. Green, of Berwick.

America, appeared blue, while at Panama on 2nd and 3rd of that month, the sun appeared green. "2nd September, Trinidad, Port of Spain.—Sun looked like a blue ball, and after sunset the sky became so red that there was supposed to be a big fire. 5th September, Honolulu.—Sun set green. Remarkable after-glow first seen. Secondary glow lasted till 7.45 p.m., gold, green, and crimson colours. Corona constantly seen from September 5th to December 15th. Misty rippled surface of haze." On November 26th some remarkably beautiful twilight and after-glow effects were seen at Chelsea, London. The writer, then resident in the Isle of Wight, well remembers that one afternoon in October, 1883, the moon presented a singularly delicate bluish appearance. He remarked that the effect must be due to some exceptional medium at a great altitude.

The Royal Society's Report is enriched with six coloured plates illustrative of these effects, copies of pictures executed at the time by Mr. W. Ascroft, and contains tabulated evidence of similar sky-phenomena as supplementary to great volcanic eruptions in former times. There is also the interesting fact that at the eruption of Krakatoa in 1680, blood-red skies were, shortly after, visible from Denmark.

Fig. 4.—Outline Section, viewed from S.W., showing position of volcanic cones upon Krakatoa after the Eruption.

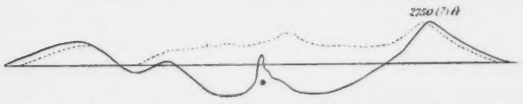

Fig. 5.—Outline of present crater. The dotted line shows the portions blown away and changes effected by lava.

It remains to be said that when this now famous island was visited shortly after the eruption of August, 1883, great changes were noted. The whole northern and lower portion of the island had vanished, except an isolated pitchstone rock, ten yards square and projecting out of the ocean, with deep water all round it. "At the same time, a large portion of the northern part of Rakata was blown away or destroyed, and a nearly vertical cliff formed." See Figs. 4 and 5. In fact, a "magnificent section" had been made of this basaltic cone, and hence "there is afforded a perfect insight into the internal structure of the volcano."—*Roy. Soc. Rep.* The coloured plate in the album to Dr. Verbeek's work, entitled "Krakatau," represents this aspect. Such a unique picture is a noteworthy contribution of art to the literature of physical science. What a tremendous work of evisceration that must have been is attested by the present condition of the island. Where Krakatoa Island, girt with luxuriant forests, once towered from three hundred to fourteen hundred feet above the sunlit waters, it is now, in some places, more than a thousand feet below them.

THE GOLDEN EAGLE.

CONSIDERABLE interest is just now being awakened amongst naturalists and in the press, on the subject of photographing birds and their nests. The October number of Knowledge contained a reproduction of some young kestrel hawks, while in the present number we reproduce a photograph of a golden eagle's nest containing two young ones.

This photograph was taken some time ago for the late Lord Colin Campbell, and was kindly sent to us by Mrs. Tweedale, an enthusiastic bird-lover.

The nest, which was built on the ledge of a cliff at Benmore, in the Isle of Mull, was of easy access, so much so that Mr. McDonald, the keeper at Benmore, writes that it "can almost be walked into along the ledge of rock on which it is built." As a rule, the golden eagle builds on a cliff or crag in some wild, mountainous glen. On rare occasions it builds in a tree, and Mr. Howard Saunders says that it sometimes nests on the ground. We doubt if there could be any nest on the ground in the British Islands now! The bird has been almost exterminated from this country by means of gun, trap, and poison, and it is only during the last few years that it has received protection. At the present time a good many eyries exist in the Highlands of Scotland, and we are thankful to say that most of them are jealously guarded by the proprietors of the land. By such means this noble bird will, no doubt, long continue to exist as a British species. In Ireland it receives little protection, and consequently there are only a few pairs left, and they nest in the wild regions of the west and north.

About two hundred years ago the golden eagle bred in Derbyshire and Wales, and little more than a century has passed since it nested in the Lake District, but we suppose that it will never again be induced to take up its quarters south of the Border, or even in the Lowlands of Scotland, although it does occasionally visit the latter in winter. In the summer the golden eagle moves about but little. The same site, indeed the same nest, is used year after year as a breeding place, though perhaps not always by the same two birds. One of the pair may be killed, but the other mates again, and so for years the same eyrie is tenanted. The nest in the photograph, we are told, has been used for at least thirty years.

The nest itself is a huge rough structure—a platform of sticks and heather, with a soft lining of moss, dead fern leaves and dry grass. It is often five feet in diameter, and is always strewn with prey and the remains. In our illustration a lamb's head can be distinctly seen, and the fur from no doubt innumerable hares and rabbits. Grouse and other birds, also fawns, form prey for the eagle, and he will sometimes attack and kill sickly ewes and deer. But it is sad to have to say, that this noble bird is a great carrion eater, which propensity, together with his "ordinary looking" appearance when perched, has detracted from his merits in the eyes of some naturalists. Mr. Seebohm goes so far as to liken him to a vulture, and says that "his motions are sluggish, cowardly, and tame compared with the death-swoop of the peregrine, or the brilliant performance of the sparrow-hawk or the merlin."

Perhaps we have gone too far in dubbing the golden eagle the "King of Birds," yet he is not the only king that fails to fulfil the conditions of an ideal monarch. We cannot better understand why he has been entitled the "King of Birds," than when we see him swooping round on outstretched wings soaring into space. It is, indeed, an awe-inspiring sight. A great dark bird, fully six feet across the wing, suddenly appears above us, and we watch as, with no perceptible movement of the outstretched wings, he soars round and round in great circles. Higher and higher he mounts, and smaller and smaller he appears to grow, until he seems no bigger than a sparrow, and then we see nothing but a black dot, which itself disappears, though barely ten minutes ago the bird's great shadow fairly startled us.

This habit of soaring, which the eagle shares with the

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raven, vulture, pelican, and stork, and many other large birds, is a vexed point with students of flight.

How can a bird overcome gravity and mount high into the air with no apparent effort or action of the wings? Exactly how, no one knows. Many theories have been advanced. The most plausible we will briefly state.

A certain amount of wind seems, to begin with, essential to soaring flight. The theory of upward currents of air accounts, undoubtedly, for soaring under certain conditions. As the wind encounters, say a cliff or mountain, or even a house or other erection, it produces an upward current of air. This is taken advantage of by birds and they are enabled, by its help, to soar upward without strokes of the wing. For instance, when there is a sea breeze, gulls may often be seen soaring above the cliffs against which the wind is striking. But this will not account for eagles, vultures, and adjutants soaring over a sea or level plain. To explain this, another theory has been advanced by Lord Rayleigh, which is clearly explained in Prof. Newton's "Dictionary of Birds," and in Mr. Headley's "Structure and Life of Birds," to which we would refer the reader for more exact information.

It has been proved that the surface of the earth retards the motion of the wind, and thus that it gradually increases in velocity as we get higher in the air. Suppose a bird, which is soaring, has been ascending against the wind, and is just about to turn round and descend with the wind. In so descending it passes into strata of air, the velocity of which lessens towards the earth, and so the more the bird descends, the faster does it go in proportion to the air, and thus it gains a greater velocity over the moving air than if there had been no wind at all. Now it swoops round, and, with its increased velocity, faces the wind, which lifts it, and the higher it gets, the stronger the wind becomes, and, consequently, the greater resistance (which is the lifting force) does it encounter. So the bird rises, and when its velocity is expended, it turns and goes "down wind" again to repeat the experiment. This seems a very plausible explanation of the wonderful soaring flight, but it may be doubted whether the wind varies to a sufficient extent at the great height from the earth to which birds will soar to fully prove the case.

The eggs of the golden eagle vary to a considerable extent in colouring. They are usually bluish-white in ground colour, and marked with reddish-brown. Two or three eggs are laid very early in the year, often at intervals of several days, and, since the birds begin to sit as soon as the first egg is laid, one may sometimes see in the same nest an unhatched egg, a young one covered with white down, and another partly feathered.

In our engraving it will be noticed that the two young birds which the nest contains, have a band of white at the basal part of the tail, which fact has led to the young bird being sometimes called the ring-tailed eagle.

THE FILTRATION OF WATER—II.

By Samuel Rideal, D.Sc. Lond., F.I.C., F.C.S.

In a previous article under the above title,* I have discussed some of the methods of water filtration which have been adopted in recent years in the larger towns in this country and on the Continent, and have shown that modern research has established the conditions under which a town supply may be purified on a large scale. The filtration works of a water company or municipal authority can, however, only be regarded as the first line of defence taken by the community to ensure better hygienic conditions of life, since these filtration works, however efficient, do not ensure absolute freedom from the risks attending the consumption of impure water. In the first place it is necessary to point out that the methods of purification adopted by the suppliers of water do not ensure absolute sterility of the water. The most efficient of the large filter beds only remove a fraction of the bacteria present in all waters which have been exposed in a river, or otherwise, to contaminating influences.

Although it is obviously the duty of such corporations to render the water supply as free from bacterial impurity as possible, their chief duty is to choose a source of supply which shall be in other respects suitable for drinking and domestic purposes. A town supply, then, should be chosen in regard to its chemical composition rather than in regard to its bacterial contents, since, as I hope to be able to show in the present article, it is possible for every householder to purify his water from bacterial infection, whereas it is almost impossible for each individual to purify a water which is charged with organic matter and with metallic salts of a more or less injurious character.

It is, therefore, a matter of the first consideration for the authority supplying the water to see that it is comparatively free from organic matter, and compounds like nitrates and nitrites, which indicate what has been called previous sewage contamination. Excess of other saline constituents is also undesirable, and the presence of large quantities of magnesium and lime salts are also to be regarded as making the water unsuitable for town purposes. Although a comparison of the death rates of towns supplied with hard waters, and those which contain little or no magnesium and lime salts, does not show that the two classes of water have any marked difference upon the health of the consumers, there seems to be evidence that hard waters are not desirable for many individuals to habitually consume, and as they are unsuited for many manufacturing processes and wasteful and unpleasant for laundry and washing purposes, no large town should have such a supply. It is also highly important that the water chosen by an authority should be without action upon lead or iron pipes, since cases of plumbism have been frequently met with from want of care in attending to this special point. As very soft waters are, as a rule, more likely to dissolve lead, and especially if the supply is an intermittent one, it follows that whilst very hard waters are to be avoided, those of great purity, so far as lime salts are concerned, are likewise unsuitable for municipal purposes. If it is found impossible to find within reasonable distance a supply which fulfils all the above conditions, it is then the duty of the suppliers to adopt means whereby these difficulties may be overcome by erecting plant, say for chemically treating the water or softening it before it is submitted to filtration. Any corporation or water company will be properly discharging its duty to the public when it has ensured the chemical purity of the supply and then submitted it to sand filtration so as to reduce the number of micro-organisms to a few per cents. of those originally present in the unpurified water. Further efforts on the part of the supplier are unnecessary so far as the quality of the water is concerned, but should rather be directed towards ensuring an adequate quantity of water of constant service. Although under these conditions a town will be supplied with a water of good chemical quality, comparatively free from bacteria, and well filtered, yet in its passage from the works to the consumer it may become contaminated with the bacillus of typhoid or cholera, or some other

* Knowledge, 1895, p. 80.

pathogenic organisms. This contamination may be caused by leakage from drains in the neighbourhood of the supply pipes, or by aërial infection of cisterns. It is on these grounds chiefly that at the present time the sterilization of water at the supply works is not advocated, and only the partial bacterial filtration aimed at. The possibility of pollution from these two causes renders it highly important that some adequate system of domestic filtration should be adopted by every householder. Unfortunately, the majority of household filters are worse than useless, since many of them do not effect the removal of the contaminating bacteria, and often, by forming a nidus for their growth, contribute to their development and multiplication in the water sought to be purified by their means. If we take, therefore, the primary duty of a domestic filter to be that of delivering sterile water, it follows that no filter should be purchased without a guarantee from the vendor that it is so constructed as to yield permanently sterile water. Most of the manufacturers are now alive to this standard, and few of the older forms of filter, in which charcoal, sponge, or asbestos, or other similar material was employed as the filtering medium, are now in the market. In filters, as in everything else, the survival of the fittest obtains, and the makers of the older forms see their business gradually disappearing as sounder knowledge on these matters becomes more general. That this efficiency is a possible one has been shown by the recent development of the manufacture of what are called candle-filters of unglazed porcelain or earthenware. These filters are the outcome of experiments made in 1871 by Tiegel, a pupil of Klebs in Berne, and by Pasteur, who found that plates of plaster of Paris were efficient in sterilizing bacteriological fluids. The first candle-filters were made privately for such experimental purposes, and were also used by Koch in Berlin, where they are still manufactured by the Sanitäts Porzellan Fabrik at Charlottenburg, and in this country, filters of a similar composition to those used by Koch are made near Manchester. The advantages of filters of this construction were so obvious that Pasteur in Paris was led to study the question and considerably improved on his original idea, which, in the hands of Chamberland, has given rise to the Pasteur-Chamberland pattern, which has been extensively adopted by the French Army, and is now well known in this country. Both the Pasteur filter and those manufactured in Germany are now made of earthenware. Other materials have been used for the production of candle-filters besides clay. Of these modifications, the best known in this country is the Berkefeld-Nordtmeyer filter, which is made of infusorial earth. These candles cannot be sterilized by baking, like those made of clay, as they are more fragile and are liable to fall to pieces. They can however, be readily and conveniently sterilized by placing them in cold water and then gradually heating the water to the boiling point and allowing the candle to remain at this temperature for three or four hours. Dr. Guinochet, in reviewing the evidence on filters of this pattern, concludes that the material from which they are made makes it difficult to ensure absolute sterility in the filtrate in all cases, and several investigators have shown that infusorial earth has also the disadvantage of allowing the organisms which are retained by the filter to subsequently grow through the walls of the candle, and thus contaminate the filtered water after the filter has been in operation for some days. This difficulty can be overcome by periodically re-sterilizing the filter, but any such procedure is open to the objection that it is impossible to know, without an actual bacteriological examination, whether the filter is yielding sterile or re-contaminated water after it has been at work for some time. Dr. Plagge suggests that for household use two Berkefeld filters should be used and sterilized alternately every day. Mons. F. Garros has also suggested the use of asbestos for the construction of candle-filters, and these are now known in France under the name of the "Filtre Mallié." Experiments with these filters have shown that they yield an absolutely sterile filtrate, and that they filter very rapidly. They can be used in conjunction with a preliminary purifier of charcoal or glass wool, which, by removing the suspended particles in the water, prevents the fine pores of the asbestos porcelain from becoming too rapidly choked. At present, however, the Filtre Mallié has only been a short time before the public, and prolonged experiments upon its efficiency are not yet available. It seems, however, to be likely to rank as one of the filters which can be safely used without fear of breaking down after long action, and if the inventor could succeed in rendering the material a little less fragile, it would be one of the best filters at present introduced. I understand, however, that this fragility has been in part overcome by making the candles of a mixture of kaolin and asbestos, so that the composition of the filtering material will approach more and more closely as the percentage of kaolin is increased to that used in the Pasteur-Chamberland filters. In all these candle-filters, even when they are used under a head of water, the rate of filtration is comparatively slow. On the other hand, if by their use an absolutely sterile filtrate can be ensured, they are to be preferred to all forms of filters which yield a larger supply of water per hour, but which do not profess to remove the whole of the micro-organisms present in the water. This difficulty has been overcome by using several candles instead of one, and thus having what is termed a battery of filters of any desired number. In selecting a filter, then, the principal point to attend to after one is satisfied that initially the filter yields sterile water, is the length of time that such a filter will remain in an efficient condition. This varies with the different kinds of material employed, and although the present evidence seems to show that the kaolin candles, as manufactured by the Pasteur-Chamberland Company, are the best in this respect, they also may allow organisms to grow through them if they are not periodically cleaned. The Berkefeld filters are known to allow this growth through to take place in a very short time, and whenever they are used they should be frequently sterilized.

All candle-filters are open to the objection that they may be imperfectly baked or cracked subsequently, and thus allow the passage of unfiltered water into the filtrate. A very good test as to whether such a faulty filter is being used or not is to connect it with an air pump, and note the pressure of air required to produce a current of air bubbles through the filter placed in a jar of water. A Pasteur-Chamberland filter may be considered faulty if it allows air bubbles to pass with a less pressure than eight pounds above the atmospheric pressure, or half an atmosphere. Other materials will not withstand such a pressure, and it is in those cases that one finds the micro-organisms passing through the filtering material. A filtered sterile water is, of course, likely to become again contaminated if it is exposed to the air, and it is therefore desirable, with filters which only yield their water at a very slow rate, that the receiving vessel should be protected from the air.

In testing a filter for its power of arresting bacteria, it is important to recollect that many natural waters have not the power of sustaining the life of certain specific organisms, and it is therefore essential, in forming an opinion upon the reliability of such evidence, that control experiments should be simultaneously recorded, showing that the particular organisms used in the filtering experi-

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ments were capable of living in the water examined under the same conditions of temperature, &c., that the test is performed under.

Besides the filters having a candle form, there are a few existing at the present time which are successful in reducing the number of micro-organisms present in a water, although not able to produce absolute sterility. Thus, for example, certain filters are now being introduced which have for their filtering area a disc of natural stone, which it is believed has the power of arresting a large percentage of the micro-organisms naturally occurring in water. These discs must, however, vary in efficiency with the nature of the stone, and also the thickness employed, and so far as I am aware no accurate experiments in this direction have been published.

Under the name of "nibestos" another similar filtering medium has been designed, which consists of asbestos pulp pressed into thin sheets, or filtering discs, which are supported upon an earthenware or glass plate containing a number of holes. Such a filter acts like a Gooch crucible, frequently used in analytical operations, and which, if properly made, retains even the finest precipitate. Its behaviour towards micro-organisms has not been sufficiently demonstrated since Dr. Sims Woodhead and Cartwright Wood's experiments showed that the filtrate was not sterile, although the number of organisms were diminished; whereas Prof. Attfield, in earlier experiments, obtained sterility. At the present time the nibestos films are being made much thicker, so presumably they give better results, but there has not been published any direct evidence upon this point. It is certain, however, that they cannot be considered germ-proof in the same sense as that term is used in connection with the Pasteur and Berkefeld filters.

It is impossible in the present article to discuss the alternate method of sterilizing water, viz., by the action of heat. It may be that eventually all filters will be discarded in favour of heat sterilization. I have already endeavoured to show that, with the exception of only a very few types of filters, their use is worse than useless, as they rendered the water liable to an increased instead of to a diminished contamination. The boiling of water and milk is always a ready and efficacious method for destroying germs, and unless a filter can be constructed which will continue to give sterile water without much attention, the boiling of the daily drinking water has a good deal to be said in its favour. Apart from this easy method for ensuring freedom from water-borne disease, within recent years several methods of sterilizing water by heat on a large scale have been brought to perfection. These sterilizers, as they are called, are gradually finding their way into hospitals and dispensaries, as well as into private houses and for technical purposes, owing to the fact that their simplicity of construction and reliability more than compensate for the cost of fuel required for working them.

WHIP-SCORPIONS AND THEIR WAYS.

By R. I. Pocock.

ALTHOUGH, as their name implies, the whip-scorpions offer a strong superficial resemblance to the true scorpions, they are in reality more nearly allied to the spiders. The most obvious points of likeness between them and the scorpions lie in the fact that the appendages of the second pair have lost their leg-like appearance, and have been transformed into powerful prehensile organs or pincers, and that the abdomen is composed of a series of distinct segments, the posterior of which are narrowed to form a stalk, bearing a many-jointed thread-like tail, which undoubtedly corresponds morphologically to the scorpion's poison-sting. But to all intents and purposes the resemblance ceases here; for if we refer to the embryological history and to other structural details, we find striking features of similarity between the whip-scorpions and the spiders. In both, for instance, there is a narrow waist separating the thorax and abdomen, and in both the abdomen is provided with but two pairs of breathing sacs, whereas in the scorpions there are four pairs of these organs; and in neither is there a trace of those curious abdominal appendages, the combs, which are so characteristic of scorpions. So, too, in the structure of the nervous and circulatory systems, is the relationship between the whip-scorpions and spiders still further established. Nevertheless, the special characters of the former are sufficiently well marked to allow of their being separated as a distinct order from the spiders or Araneæ. This fact was long ago recognized by Latreille, who proposed to include the whip-scorpions or *Thelyphonidæ* and the *Phrynidæ* in his order *Pedipalpi*. The name "pedipalpi" or palp-footed was ascribed to these families of Arachnida in allusion to the peculiar formation of the first pair of legs. A glance at the accompanying figure of Hose's whip-scorpion (*Thelyphonus hosei*), from Sarawak, will show that the appendages in question are much longer and thinner than the rest of the legs, and that the tarsus is divided up into a series of small segments and is clawless. These limbs, in fact, are never used for locomotion, for which indeed they are quite unfitted, but take the functional place of the antennæ of an insect, and enable their possessor to learn by touch the nature of the surroundings in which it is placed. There is no doubt that this end is also partially attained in the case of *Thelyphonus*, by the long, pliable, whip-like tail, which is thickly studded with tactile hairs. In the Phrynidæ or tailless Pedipalps, on the other hand, in which this posterior feeler has disappeared, we find the want of it made good by the excessive development of the anterior feelers, which are sometimes as much as eight times the length of the animal's body, the three distal segments of the limb being transformed into a long, many-jointed antenniform lash, which can be projected with equal ease forwards, backwards, or sideways, the two together covering in large specimens an area upwards of twenty-four inches in diameter.

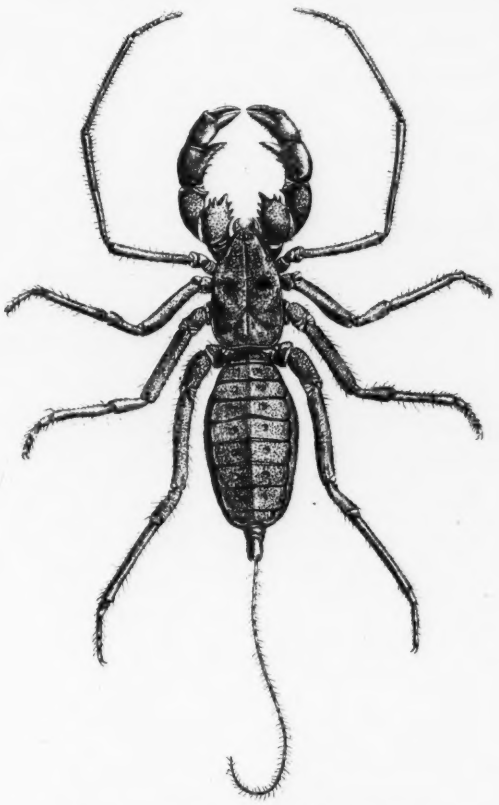
The whip-scorpions have no poison glands for killing prey, such as are possessed by spiders and scorpions, but they speedily slay insects with the deadly embrace of their pincers, which are armed for the purpose with stout, horny spines.

The adult males are very different from the females in appearance, being smaller and thinner in the body and having the pincers much longer and stouter. The reason, however, of these structural differences in the pincers is not yet understood.

The geographical distribution of these animals is both interesting and puzzling. They range in south-eastern Asia from Japan and the River Amur in the north to South India and Ceylon in the south. Thence in an easterly direction they spread throughout the islands of the Indo- and Austro-Malayan Archipelagos, including the Philippines, as far as the Fijis and the New Hebrides, perhaps just touching the north of Queensland on the way. But from the greater part of Asia, the whole of Europe, of Africa, including Madagascar, of Australia, with the above-mentioned exception, and of New Zealand, they are, so far is at present known, entirely absent. In America their distribution closely resembles that of scorpions and other tropical and sub-tropical groups, for they extend from the Southern States (Texas, Florida, etc.), through Mexico

and the West Indies, certainly as far as the southern portions of Brazil.

Of the palæontological history of whip-scorpions but little is known. A few specimens, however, from the carboniferous beds of Bohemia and Illinois show that, like



Hose's Whip-Scorpion *(Thelyphonus hosei)*.

the scorpions, these animals have existed on the earth with but little change in structure from that remote period until the present time.

Our knowledge of the habits of the Thelyphonidæ has been greatly increased during the last few years by observations made of different species living in America and in the East Indies.

Mr. E. W. Oates, who has perhaps collected more of these animals than any other man living, tells us that in Burma they live under timber and stones, or at the roots of trees under accumulated dead leaves and rubbish, lying concealed during the daytime and creeping about at night only. They certainly require moisture, but must have well-drained soil. Prof. Wood-Mason, however, goes a step further than this and affirms that he found them only during the heaviest rains, when the soil and surrounding vegetation was saturated with water. He noticed, too, that they soon die when removed from their humid haunts, and from this circumstance it was inferred that air laden with moisture is necessary for respiration. We are told, on the contrary, by Mr. Schwarz, that in Florida a species is found in dry, sandy localities: and if we are to allow credence to these somewhat irreconcilable statements, it would seem that the American and the Indian species differ considerably in constitution.

Like many animals which have a reputation for scarcity, whip-scorpions seem abundant enough if the observer knows where to look for them. Mr. Oates says that upon one occasion, while visiting Double Island, which lies off the coast of British Burma, he and a friend secured no less than three hundred and sixty specimens during a three hours' search.

All the known species appear to be nocturnal, spending the day in hiding beneath stones, logs of wood, etc. But there is no doubt that some species dig for themselves holes in the ground, which are used as permanent places of abode. Mr. Pergande, of Washington, who kept in captivity a specimen of the North American species, *T. giganteus*, put it into a jar, the bottom of which was covered to a depth of about ten inches with sand. The animal, after first making a tour of exploration, began to dig a burrow. Choosing a place where there was a slight hollow, it started scraping the sand together from a particular spot with one of its great pincers. It then used both of these organs for the same purpose, and, dragging the sand backwards some distance from the spot, proceeded to smooth and level down the heap, the object of this action probably being to prevent an accumulation of sand near the mouth of the burrow. The animal repeated this operation until it had dug out a tunnel from two to three inches deep, the inner end being about an inch and a half below the surface. The completion of the burrow, however, took several days, the operator seeming to require many rests between whiles.

When on the prowl the animal moved about the jar very cautiously and slowly, with its great pincers outstretched in readiness to grab anything edible that it might come across, the first pair of legs, or feelers, being kept in constant and active motion, touching all objects within reach. Upon perceiving the presence of a cockroach, the *Thelyphonus* either stopped or moved scarcely perceptibly, but not being active enough to catch so agile an insect by speed of foot, it adopted a cunning device to gain its end. Waiting near the cockroach with extended nippers, it stretched out its long front pair of legs, and by cautiously tapping the insect on the further side gradually induced it to advance within reach of its pincers; then suddenly grasping it with these organs and crushing it to death in their strong embrace, it carried away the victim to be devoured at leisure in its burrow.

The late Dr. Marx also kept in captivity a specimen of this species, which was supposed to be only a few days old when captured. It started to dig a home for itself in the sand within twenty-four hours of its being put into a glass jar. The burrow was luckily made close to the glass wall of the jar, so that the animal was kept constantly under observation. It devoured on an average one or two small cockroaches per week, but did not appear to drink any of the water with which it was supplied. In this respect it resembled scorpions which never seem to require water. For about three months during the coldest part of the year this animal closed up the aperture of its burrow and stayed in the deepest part, which had been enlarged for the purpose. But during this period of quiescence, it did not lapse into a lethargic or dormant state as is usual with hibernating animals, but stood quietly in its retreat, sensitive to the slightest disturbance. In their natural surroundings, however, these animals do not always bury themselves in the winter, for during a spell of cold weather in Florida, Mr. Schwarz found them under logs, apparently in as active a condition as in the summer.

At the breeding season, Dr. Strubell tells us, the female of *Thelyphonus caudatus*, which is common in Java, buries herself a foot or more deep in the ground and there lays her eggs, which she subsequently carries about attached to the lower surface of her abdomen. The young when first

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hatched much resemble the parent, and during growth undergo a series of moults like spiders, scorpions, and in fact all Arthropoda. But the process of growth seems to be a slow one. According to Dr. Marx, his young specimen, above referred to, grew less than an inch in two years. The moulting is effected as in scorpions and spiders by the splitting of the skin along the sides of the cephalothorax, beneath the carapace. Mr. Oates tells us that the sexes grow up exactly alike until the final moult. But the male emerges from his last skin a very different looking animal, with longer and stronger nippers, and thinner body.

Like many other harmless animals, the whip-scorpions have been accredited with the possession of poison glands, and in America there are even stories to the effect that horses have been known to die from the effects of their sting. They may, however, be handled with perfect impunity, and dissection fails to reveal the existence of poison glands. They have, nevertheless, a remarkable means of defence in a pair of stink glands which open upon the last segment of the body at the root of the tail. These glands discharge a liquid, the odour of which is said to resemble acetic acid or aromatic vinegar, and is so powerful, Mr. Oates tells us, that it has frequently betrayed to him the whereabouts of the animal, and, according to Latreille, has earned for these creatures the title *vinaigriers* from the French settlers in Martinique. There cannot be much doubt that the pungency of this fluid renders the whip-scorpions distasteful to such enemies as insects and birds that would otherwise prey upon them. But upon an occasion when some drops of it were by chance discharged into Mr. Oates's eye, no harmful results ensued.

Another curious organ possessed by most genera of this family may be here mentioned. This is the pair of clear yellow spots found on the last segment of the abdomen. The function of these is at present unknown, but it has been suggested by Dr. Hansen that they may be luminous organs like those to be seen on the firefly. But so far as is at present known, this supposition has no foundation in fact.

Notices of Books.

Studies in the Evolution of Animals. By E. Bonavia, M.D. Pp. 362. (Constable & Co.) It seems to us that Dr. Bonavia gives himself away in the first paragraph of the preface to this work, for therein he says: "Having completed the *Flora of the Assyrian Monuments and its Outcomes*, I was looking about for something to take up next as a subject of study. In the furriers' windows I was attracted by the leopard and tiger skins, which by degrees became objects of interesting study and speculation." This candid confession startles those who are old-fashioned enough to think that an author's first qualification should be a wide and deep knowledge of his subject. The subject which Dr. Bonavia happened to take up is the external coloration of mammals. To begin with, he discusses the characters of the spots and stripes on a number of mammals, and comes to the conclusion that, in the case of tigers, the stripes were derived from spots or rosettes. Following up this notion, the author derives the stripes of the zebra from the spotting of dappled horses; according to which view all horses and asses and zebras were originally spotted, or have descended from ancestors having spots not unlike those of the jaguar. These points having been settled to the author's satisfaction, the origin of the rosettes or spots themselves is tackled, and the astounding conclusion is arrived at that they represent the vestiges of bone-plate rosettes on a glyptodontoid type of mammal; in other words, Dr. Bonavia believes that the jaguar and other members of the cat tribe have descended from some extinct ancestor with a glyptodontoid carapace, and as this ancestor lost its bone-rosettes, it left behind a pattern which we see preserved in the spot-rosettes of the jaguar. The same theory is applied to account for the markings of horses and other mammals. The confidence with which Dr. Bonavia builds up such a stupendous superstructure of theory upon a slender basis of fact is simply prodigious; and how he is able to shut his eyes to the anatomical and zoological evidence which controverts it passes our comprehension. Many other far-fetched conclusions are arrived at in the book, the only redeeming feature of which is the remarkably fine illustrations. It is a pity that these pictorial embellishments should be used to prop up such wildly-speculative theories.

Practical Proofs of Chemical Laws. By Vaughan Cornish, M.Sc. (Longmans.) We have read this little book with great pleasure, as the author has shown in it that he is not only filled with the spirit of a true man of science, but is also fully acquainted with the difficulties which attend the imparting of that knowledge to others. His exercises are carefully chosen, and as they are the actual details of his own class experiments, there should be no difficulty in their adoption by other teachers. We hope that the time is not far distant when test-tubing will cease to be designated chemistry in our public and secondary schools, and that text-books of this practical description will be used by teachers, so that the laws and foundations of the science will be taught, and thus aid in sorting out from the common herd those who are naturally gifted in the scientific habit, and enable them to be selected by their masters for further training and development.

The Natural History of Aquatic Insects. By Prof. L. C. Miall, F.R.S. Pp. 395. (Macmillan.) Signs are not wanting of a reaction against that method of studying zoology which confines the observations to the laboratory, and in favour of those broader lines of study followed by the great naturalists of the seventeenth and eighteenth centuries. England is the home of observers who take a delight in investigating the structure and habits of animals, though their observations are not always properly appreciated by systematic zoologists. Prof. Miall's attractive volume will, we are glad to say, induce many to join the ranks of the old type of naturalists, and will help to systematize the observations of those who are already zealous, albeit aimless, students of the wonderful workings of nature. Written in a style easily understood, and by one who is able to impart sound information, the book will undoubtedly take a permanent place among works on natural history. The illustrations, many of which are from new drawings by Mr. A. R. Hammond, are like the text—good and true. We know of no better guide to the study of aquatic insects in a practical way than is afforded by this book, and there are few books which tend to bring the reader into closer contact with nature.

Petrology for Students. By Alfred Harker, M.A., F.G.S. (Cambridge University Press.) This introduction to the microscopic study of rocks in thin slices belongs to the carefully-prepared and well-produced series of Cambridge Natural Science Manuals. With the exception of Prof. Cole's "Aids in Practical Geology," we know of no English text-book on the microscopical characteristics of minerals and rocks more suitable for beginners; and as the book before us deals entirely with petrographical matters, it is even more acceptable to the specialized student than Prof. Cole's volume, which takes a larger view. The classification of massive igneous rocks adopted by Mr. Harker is into

plutonic rocks, intrusive rocks, and volcanic rocks. Each of these classes is treated in a separate section, in which the various rock-types are grouped in families founded on the mineralogical composition. The two other sections into which the book is divided refer respectively to sedimentary rocks and metamorphism. The book contains seventy-five "process" illustrations of rock sections, and though these cannot, of course, adequately represent the natural appearance, they will be of great assistance to teachers in showing structural characters. The book can be confidently recommended to students of petrology, as a clear and precise exposition of their subject.

Chemists and their Wonders. By F. M. Holmes. Pp. 160. (Partridge & Co.) The aim of the author of this volume has been "to present in a purely popular form some of the remarkable instances in which chemistry has influenced various industries during comparatively recent years." The style is conversational, and suited to the mental digestion of a juvenile public. As a book for the young, containing a number of facts about chemical arts and manufactures, the volume will probably be successful.

Astronomers and their Observatories. By Lucy Taylor. Pp. 160. (Partridge & Co.) Books on astronomy are fairly numerous, but we think there is room for this little one. The authoress writes pleasantly, clearly, and accurately, and her readers will obtain a good all-round knowledge of celestial science.

Architecture for General Readers. By H. Heathcote Strahan. Pp. 332. (Chapman & Hall.) There are many who take an interest in architecture, but lack the knowledge which would enable them to understand the different styles, and to come to an intelligent judgment on architectural designs. This treatise supplies the outlines of the principles, practice, and historical development of the art, and anyone who reads it will be able to distinguish the good from the bad in the design and construction of buildings. Mr. Strahan is the editor of the *Builder*, and therefore he writes as one who knows. His book is admirably planned and attractively written, and those who read it will not only be interested, but will be given at the same time an additional source of pleasure in life.

British Birds. By W. H. Hudson, C.M.Z.S. (Longmans.) Illustrated. Of the many bird books recently published, this volume must be ranked among the best. It is not intended as a text-book for the student, but as a book to interest the general reader, and especially the young, in the birds of our islands. Those birds only are dealt with which may be termed strictly British at the present time. Thus, of the three hundred and seventy-six so-called British species, the author has omitted from the present volume the hundred or so which may be described as "accidental stragglers," rightly concluding that a bird cannot be called "British" if it has only visited our islands on a few chance occasions. Some time ago Mr. Hudson penned a pamphlet on "Lost British Birds." In the list of birds supposed to be lost to our islands we are sure that Mr. Hudson was pessimistic, and we are glad to see that he has included in his present volume several species which he formerly considered as lost. Of these, the bittern is figured in one of the several beautiful coloured plates which adorn the book. These plates are the handiwork of Mr. Thorburn, and we have never seen better. Mr. Lodge is responsible for a number of smaller drawings—most of them finely drawn and true to nature, although some of them are too crowded. Mr. Hudson's descriptions are brief, but his words are those of a true lover of birds, and they cannot fail to interest the reader, be he young or old. The following passage may be taken as typical of the author's picturesque style:—"At all seasons the jackdaw loves to consort with his fellows, and to spend a portion of each day in aërial games and exercises; the birds circle about in the air, pursuing and playfully buffeting one another, and tumbling downwards, often from a great height, only to mount again, to renew the mock chase and battle, and downward fall." The value of the book is greatly enhanced by an excellent chapter on the structure and classification of birds by Mr. F. E. Beddard, a well-known authority on the subject.

The Splash of a Drop. By Prof. A. M. Worthington, F.R.S. (S. P. C. K.) Illustrated. This very interesting volume is a capital addition to the "Romance of Science" series. It is a reprint of a discourse delivered at the Royal Institution, a year ago. Prof. Worthington has been studying the curious phenomena for twenty years. The splash of a drop occurs in the twinkling of an eye; yet it is an exquisitely regulated phenomenon, and one which very happily illustrates some of the fundamental properties of fluids. The problem which Prof. Worthington has succeeded in solving is to let a drop of definite size fall from a fixed height in comparative darkness on to a surface, and to illuminate it by a flash of exceedingly short duration at any desired stage, so as to exclude all the stages previous and subsequent to those thus selected. The numerous illustrations in the volume testify to the accuracy and beauty of his work. The curious results of the splash of a drop of mercury from a height of three inches upon a smooth glass plate are particularly interesting. Very soon after the first moment of impact, minute rays are shot out in all directions on the surface with marvellous regularity. From the ends of these, minute droplets of liquid split off. The liquid subsides in the middle, and afterwards flows into a ring. The ring then divides in such a manner as to join up the rays in pairs. Thereafter the whole contracts, till the liquid rises in the centre, so as to form the beginning of the rebound of the drop from the plate. Immediately the drops at the ends of the arms now break off, while the central mass rises in a column which just fails itself to break up into drops. He photographed no fewer than thirty successive stages of the splash within the twentieth of a second, so that the average interval between them was about the six hundredth of a second. Remarkable are the splashes of water-drops falling about sixteen inches into milk, but more beautiful are the dome forms when the height is fifty-two inches. The study of a splash of a drop is so unique and interesting that all of a curious turn of mind should secure the little volume.

BOOKS RECEIVED.

The Structure and Development of the Mosses and Ferns. By Douglas H. Campbell, M.D. (Macmillan.) Illustrated. 14s.

A Laboratory Course in Experimental Physics. By W. J. Loudon, B.A., and J. C. McLennan, B.A. (Macmillan.) Illustrated. 8s. 6d.

Peripatus, Myriapods, and Insects. By Adam Sedgwick, M.A., F.R.S., F. G. Sinclair, M.A., and David Sharp, M.A., F.R.S. (Macmillan.) Illustrated. 17s.

A Handbook of the British Lepidoptera. By Edward Meyrick. (Macmillan.) 10s. 6d.

Natural History of the Drone-Fly. By G. B. Buckton, F.R.S. (Macmillan.) Illustrated. 5s.

An Exercise Book of Elementary Practical Physics. By R. A. Gregory, F.R.A.S. (Macmillan.) Illustrated. 2s. 6d.

Text-book of the Embryology of Invertebrates. By Dr. E. Korschelt and Dr. K. Heider. Translated by E. L. Mark and W. McM. Woodworth. Part I. (Swan Sonnenschein.) Illustrated. 15s.

British Birds' Nests. By R. Kearton. (Cassell & Co.) Illustrated.

A Hand-book of Industrial Organic Chemistry. By S. E. Sadtler Ph.D., F.C.S. (Lippincott.) Illustrated.

XUM

Outlines of Psychology. By Oswald Külpe. Translated by E. B. Titchener. (Swan Sonnenschein.) 10s. 6d.

Great Astronomers. By Sir Robert S. Ball, D.Sc., F.R.S. (Isbister.) Illustrated. 7s. 6d.

The Story of the Expansion of Southern Africa. By Hon. A. Wilmot. Second Edition. (Fisher Unwin.) Illustrated. 5s.

Movement. By E. J. Marey. Translated by E. Pritchard, M.A. (Henemann.) Illustrated.

The Merry Wives of Windsor. Fine Art Edition. (Raphael Tuck & Sons.) Illustrated. 7s 6d.

The Children's Shakespeare. By E. Nesbit. (Raphael Tuck & Sons.) Illustrated. 5s.

Photograms of 1895. Compiled by the Editors of "The Photogram." (Dawbarn & Ward.) 2s.

Mechanics. Hydrostatics. By R. T. Glazebrook, M.A., F.R.S. (Cambridge University Press.) Illustrated. 3s.

The History of Babylonia. By the late G. Smith. Edited by Rev. A. H. Sayce. (S.P.C.K.) Illustrated.

The Story of the Earth in Past Ages. By H. G. Seeley, F.R.S. (Newnes.) Illustrated. 1s.

Nature's Story. By H. Farquhar, B.D. (Oliphant, Anderson & Ferrier.) Illustrated. 2s. 6d.

Physiology. By A. Macalister, LL.D., F.R.S. (S.P.C.K.) Illustrated.

The Tallennan-Sheffield Localized Hot-Air Bath. (Baillière, Tindall & Cox.) 2s.

Classical and Scriptural Atlas. By Geo. Carter. (Relfe Bros.) 1s. 6d.

The Elephants. (A Zoological Mnemonic.) By R. J. Anderson. (Belfast: Mayne.) 1s.

AËRIAL WARFARE.

By Thomas Moy.

ALARMING notices occasionally appear in print, describing the terrific results which are likely to ensue when aërial navigation becomes an accomplished fact. The nation to which the discovery will belong is to conquer the rest of the world; dynamite, or something still more violent, is to bring into subjection or destroy every enemy; Government buildings, arsenals and ships are to be annihilated; in fact, the terrible aërial navigator is to become monarch of all he surveys, and to be able to survey to his heart's content.

When these forecasts emanate from writers upon penny papers mankind can afford to smile, and enjoy their sleep undisturbed by fears of explosive missiles kindly dropped at midnight by aërial cherubs sailing up aloft; but when men in the position of Mr. Hiram Maxim and General Hutchinson treat the public seriously in this manner, their views should be carefully studied and their arguments weighed.

Mr. Maxim represents gunnery and the aviator flying machine, pure and simple.

General Hutchinson represents the dirigible balloon and the British Army.

As Mr. Maxim possesses mechanical knowledge, he must be well aware that a flying machine, such as he has built, must have considerable velocity in order to sustain it in the air; in other words, it is not a flying machine unless it flies, and it cannot fly slowly, it must have speed. Another requisite is perfect balancing, commonly called horizontal stability; and this stability must not be rudely disturbed while in flight, otherwise the machine would speedily come to grief. Now, Mr. Maxim should be well acquainted with the flight of shot and the laws of motion. He must also be well aware that if a missile were dropped from an aërial machine while in rapid flight, its downward path would be very far from the perpendicular, and the aim would be as erratic as can possibly be conceived. An aërial "Shoeburyness" would be required to teach aërial soldiers the new art of gunnery. Having studied the subject of aërial navigation for fifty years, it appears to me a most impracticable idea to suppose that aviators could be put to any other use, for purposes of war, than that of observing an enemy, signalling, and conveying information. There is a trite old saying as to making jugged hare—"First catch your hare"; and I may here say "First make your aviator." Mr. Maxim is a long way off aërial flight, and much farther off aërial warfare, and still farther off taking aim from a height of several miles, while travelling at a high speed.

But General Hutchinson must, from his training as a soldier, be well acquainted with the art of defensive as well as offensive warfare, and he must have heard of rockets; yet he proposes to attack an enemy with dynamite from slow-sailing gas bags! Would he not, as a general in the British Army, be bound to make use of rockets if an enemy attacked this country from the regions above? Suppose an aërostat came overhead on warlike deeds intent, carrying dynamite missiles, would not General Hutchinson send up a number of rockets, and would not the aëronauts cut a sorry figure under the action of gravitation? It would not be a pleasant experience to have Congreve rockets surrounding the gas bag, and it would be very strange if one of these missiles did not enter the envelope and cause an explosion. Yet General Hutchinson writes upon this subject as though the whole business were one-sided—as though it would be all attack and no defence.

If any owner of an aërostat would like to try his hand at hitting an object from above, he can do so at any time with derelict vessels in the Atlantic, but I fear that he would get tired before he destroyed one. His ammunition would run short.

To my mind, it appears that the accomplishment of conquering the air would make for peace instead of war. Aviators would be first applied in short journeys across the English and Irish Channels, carrying a few passengers who fear sea-sickness; also in looking after disabled vessels at sea, and giving notice at seaports where to send tug-boats to aid them into port; and other useful services of a similar nature. And this is all that may be expected for many years to come.

Note.—We learn with regret, as we go to press, of the death of General Hutchinson.

Science Notes.

C. Dufour, in a paper in the *Comptes Rendus*, refers to the abnormal refraction phenomena frequently seen on the Lake of Geneva. When the air is colder than the water, fine mirages are observed; when warmer, the Castle of Chillon, which, under ordinary conditions would be invisible, even if it were twice its actual height, can be seen at Morges. M. Dufour points out that these effects would render observations on solar and stellar altitudes faulty, and suggests the compilation of tables making the necessary corrections for different temperatures of the air and sea.

The aluminium vessels now in use in the French army are found to wear very little. They can be heated over gas and coal, and are not attacked by the food and wine, &c., as the food does not remain long in the vessels. Flasks in which ordinary water is kept for months show whitish spots near specks of impurities—iron, carbon, &c., and on the soldered portions if other metals have been admixed. The vessels are made simply by stamping, without soldering, except at the handles. In salt water, corrosion of the metal proceeds more quickly than in fresh water; it becomes black, but sulphuric acid restores the original brightness.

It has often been observed that a bright scarlet uniform will appear perfectly white in a good photographic dark room with ruby glass windows. H. W. Vogel has communicated to the Physical Society of Berlin the results of some of his experiments on this subject. He used oil lamps provided with pure red, green, and blue colour screens, and found that when white light was rigidly excluded, all sense of colour disappeared to the observers, and nothing but shades of black and white could be distinguished on objects in the room. He found that a scale of colours, illuminated by red light, showed the red pigments as white or grey, which abruptly turned into yellow and not red on adding blue light. Hence a colour was perceived which was not contained in either of the sources. Herr Vogel comes to the conclusion that our opinion as to the colour of a pigment is guided by our perception of the absence of certain constituents.

A bright comet with a tail was discovered by Perrine, at the Lick Observatory, California, on the 16th November, at 17·2h. local time, its place then being: right ascension, 13h. 44m., north declination, 1° 40′. Dr. Halm observed the comet at the Royal Observatory, Edinburgh, as follows:—November 18th, 18h. 26m. 14s. Mean Time Greenwich. $\alpha = 13\text{h. } 48\text{m. } 15{\cdot}42\text{s.}$ $\delta = +\ 0°\ 48'\ 18{\cdot}8''$.

A French journal describes a new and promising substitute for gold. It is produced by alloying ninety-four parts of copper with six of antimony, the copper being first melted and the antimony afterwards added; to this a quantity of magnesium carbonate is added to increase its specific gravity. The alloy is capable of being drawn out, wrought, and soldered just as gold is, and is said to take and retain as fine a polish as gold. Its cost is a shilling a pound.

M. D'Arsonval finds, from his experiments on the torpedo, that muscular contractions and electric discharges are closely connected, and that the muscle and the electric organ obey the same laws. In his observations the animal was placed on a metal plate and tinfoil electrodes were applied to its back. When the torpedo was slightly pinched, six or ten discharges of a duration of $\frac{1}{20}$ to $\frac{1}{10}$ of a second, followed one another at intervals of $\frac{1}{100}$ of a second. Currents strong enough to light up incandescence lamps were obtained. After a few discharges the organs of each side, which function simultaneously, are exhausted, the exhaustion taking place in the electric organ, and not in the nerve.

As the result of observations made at the observatory on Mount Hamilton, W. W. Campbell came to the conclusion last year that no aqueous vapour is contained in the atmosphere of Mars. This is quite a different opinion from that to which Janssen was led by his observations, published in 1867, which have been recently re-published in the *Comptes Rendus*. In 1862, Janssen discovered the spectroscopic bands caused by aqueous vapour in our earth's atmosphere, these having been previously observed by Brewster in 1833. From the 12th to the 15th of May, 1867, after having first of all made himself familiar with the bands due to aqueous vapour, he made observations on the summit of Etna. On the 13th the cold was excessive, and the quantity of vapour in the earth's atmosphere was very small—not enough to make visible the lines in the solar spectrum called group C, and still less group D. When Mars was examined, groups C and D, although feeble, were distinctly visible. It was in consequence of this observation, confirmed later at Palermo and Marseilles, that Janssen announced the presence of the vapour of water in the atmosphere of Mars.

Rev. Samuel Barber writes to us as follows: "Aurora Borealis was seen at Whitstable-on-Sea from seven to eight on Saturday evening, November 9th. It was in the form of a low, long, elliptical band, extending over the northern horizon, and having its vertex or highest point nearly under the double star in Ursa Major. The colour was red. No streamers could be observed. The writer, during the afternoon, had been struck by the rapid formation and quick motion of matted, loose-textured cirrus and cirro-cumulus drifting from the south. The weather was very mild the following day; gusty, with sudden showers, on Monday, when lightning was seen on the horizon, both east and west."

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

INDIRECT SOURCES OF HEAT.

To the Editor of KNOWLEDGE.

SIR,—It has frequently occurred to me, that in books bearing upon the subject of the various sources of heat, especially as regards the climatic conditions of a country, a very important item is omitted. The one I refer to is the heat generated by the frictional action of water.

It may be that the books I have met with have, when compared with others, dealt with the matter only in a superficial manner; and it is in the hope that some of your readers may be able to tell me of a more complete work that I now mention the subject.

Everyone is taught, from his geography book, that the clemency of a country's climate is greatly enhanced by an insular position. This, because (putting aside effects produced by ocean currents) water absorbs heat much slower, but retains it much longer than does the land; consequently the latter is dependent for much of its warmth in winter, when it has lost all its own summer heat, upon its surrounding ocean blanket. Besides this, no mention is made of any other warmth-governing cause, and it is here where I think an important factor has been missed.

The heat which I have already referred to is that produced mainly in the three following ways:—

1. By friction caused by tides, depending upon the attracting forces of the sun and moon.

2. By friction caused by waves, depending upon the action of winds.

3. By friction caused by running water, depending upon the gravitation of the earth.

The first is the most important, because it is general and perpetual in its action. The amount of frictional heat generated by this means alone, in the course of a year, must be stupendous.

Although small in size, the moon is so close to us as to have the greatest influence upon our tides. Thus, indirectly, we must owe a great deal of our warmth to a cold, burnt-out orb.

The warmth caused by wind-waves must also be very considerable, and where breakers are constantly falling against a rock-bound coast, I should imagine that enough heat to have an appreciable effect would be produced.

Besides, in both these cases, it is the surface water almost entirely which is disturbed. This, when warmed, would be lighter than the colder layers beneath, and, in a broad sense, would always remain uppermost, to be shaken up over and over again, and to radiate off slowly its store of heat-energy into the atmosphere.

The last source, when compared with the other two, is hardly worthy of mention, but in some countries, where

waterfalls are of very frequent occurrence, I should think the effect would be noticeable. Is it not probable that Norway, for instance, would be appreciably colder, were it not for its thousands of waterfalls?

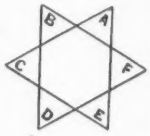
Yours faithfully,

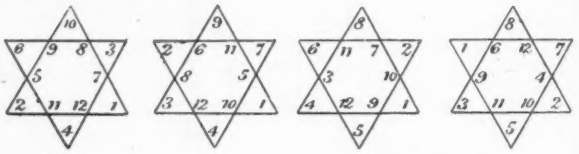
Boldmere Road, Erdington. ALFRED J. JOHNSON.

THE PUZZLE OF "26."

To the Editor of KNOWLEDGE.

SIR,—It is easy to see that the solution of this problem necessitates the condition that A+C+E=B+D+F, and that one of these groups must sum 13. Then in the numbers 1 to 12 there are only eight groups of three numbers each which fulfil this condition; they are as follows:—10, 2, 1—9, 3, 1—8, 3, 2—8, 4, 1—7, 4, 2—7, 5, 1—6, 5, 2—6, 4, 3.





Paris. UN VIEIL ÉTUDIANT.

To the Editor of KNOWLEDGE.

SIR,—Referring to the problem in your last number, I find that—

(1) The numbers in the hexagon must comprise the number 1, since the sum of the next six lowest numbers is greater than 26.

(2) That the remainder, 25, may be gained either from 3, 4, 5, 6, 7, or from 2, 4, 5, 6, 8.

(3) That the latter must be taken, because 3+11+12 are required for the angles of one of the triangles.

Hence a little consideration leads to the following solution:—

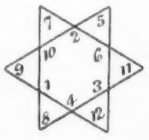
26−(12+11)=1+2
26−(11+ 3)=4+8
26−(12+3)= 5+6

26−(10+9)=6+1
26−(9+7)=2+8
26−(10+7)=5+4

J. WILLIS, Ph.D.

To the Editor of KNOWLEDGE.

SIR,—I have found one solution of the above puzzle. It is thus:—With regard to the *modus* of solution it is simple. The S in A P of figures 1 to 12 is 78, the outer ring twice the inner. Take the last six numbers, this gives five too many; exchange 5 for 10, and place the numbers in outer angles. Adjust the inner ones in alternate angles round, 4 next 3, and on to 6.



T.

[Of the solutions sent in by your three correspondents, I note that two—"T" and "J. Willis"—proceed on the principles, first, that the outer ring shall be double the inner ring, and, second, that the number in each outer angle shall equal the sum of the two numbers directly opposite; while "Un Vieil Étudiant" proceeds on the principle that the inner ring shall be double the outer ring, which necessitates the giving up of the second condition. Both solutions seem good, though they are not only different, but different in results.—I. G. OUSELEY.]

THE DARK HEMISPHERE OF VENUS.

To the Editor of KNOWLEDGE.

SIR,—In connection with the letter by M. Antoniadi, which appears in the November number of KNOWLEDGE, I may perhaps be permitted to refer him to one of my own, on page 135 of your XVIIth Volume.

Uckfield. WILLIAM NOBLE.

PHOTOGRAPHS OF NEBULÆ.

To the Editor of KNOWLEDGE.

SIR,—The stereoscopic method for examining stellar photographs, which was referred to by Mr. E. Holmes in the November number of KNOWLEDGE, was tried some three years ago by Mr. W. Crookes, F.R.S., with the object of detecting stellar parallax; but the original negatives should be used for such purposes, because the quantities to be dealt with would be very small.

I have examined many stellar negatives taken at different periods in duplicate, and have also examined many thousands of the stars upon them by superposition of the plates, but have not found any indication of displacements of the stellar images due to irregular contraction of the gelatine films.

Those who may engage in the examination of the stellar photographs published in KNOWLEDGE should be careful in distinguishing between instrumental distortion of the images of the stars, and the appearances caused by the overlapping of the photo-images of double and multiple stars; and it would further the real useful work that may be done in utilizing the photographs, if some simple experiments and tests were made by the *researchers* themselves before too readily yielding to the impulse of writing—suggesting doubts and difficulties, many of which they would soon find to be imaginary only. When a real difficulty appeared, then the enlarged positives-on-glass, or the original negatives, could be referred to, or another photograph taken, and in this way the difficulty removed.

Crowborough. ISAAC ROBERTS.

[The readers may here be reminded of the care which Dr. Roberts always takes to provide the co-ordinates of at least four fiducial stars on each plate. The fiducial stars themselves are marked by minute ink dots, thus:—(·), (··), (·.·), (::).]—ED.

NOTE.—The concluding portion of Mr. Maunder's article, entitled "What is a Nebula?" (the first part of which appeared in the November number of KNOWLEDGE), will be published in the January issue.

NEW STARS.

By Dr. A. BREWSTER, Junr.

IF my suggestion in the November number of KNOWLEDGE be accepted, and the periodical luminous phenomena of the sun and the red variables can be explained by the periodical dispersion of cloudy matter R by heat due to a new combination of gaseous molecules A and B, "new stars" need no other explanation. In their sudden upblazing and gradual fading away we see once more the sudden evaporation and gradual reappearance of dark condensed matter shutting off the light from the still glowing interior of the star, and in their strong bright lines we see a vigorous luminescence, as a testimony to the greatness of the chemical force that was needed for a work so enormous as the dispersion of a dark crust, perhaps many centuries old. A work so gigantic is not likely to be practicable at once. It will proceed gradually with intervals, and so cause the new star to show its well-known fluctuations.

As now under the never-ceasing loss of the star's heat by radiation the vaporized crust condenses again, and so

shuts off the always-glowing interior, the star's continuous spectrum vanishes, but the bright line spectrum will not disappear, since it has its origin in the external atmosphere overlaying the crust, where, under the influence of the now rapid cooling, chemical association still continues and so produces a discontinuous spectrum giving to the extinguished new star the appearance of a planetary nebula.

This appearance has been discovered in Nova Cygni by Lord Crawford, in Nova Aurigæ by Gothard, in Nova Normæ by the astronomers of the Harvard College Observatory. According to Dr. and Mrs. Huggins, the spectra of nebulæ and novæ have no real resemblance, for in the position where the nebulæ show their narrow and defined lines they found in Nova Aurigæ, February, 1893, extended groups of lines (*Proc. Royal Soc.* 54, p. 30). But since February, 1893, the spectrum of Nova Aurigæ has shown very interesting and significant changes, and now, according to the numerous and complete observations of Campbell at the Lick Observatory, is approaching the average type of nebular spectrum (*Astroph. Journal*, Jan. 1895, page 50). This remarkable assertion of Campbell has suggested to me the following idea: If extinguishing stars show the spectrum of gaseous nebulæ, then star clusters, where the great majority of stars are extinguishing, will also show such a spectrum. Thus if we assume that different clusters can be of different ages or more or less approaching their final extinction, then the younger irresolvable clusters will show a substantially continuous spectrum, as does the great nebula in Andromeda, and the elder irresolvable clusters will show a gaseous spectrum, as does the great nebula in Orion. If the spectra of gaseous nebulæ, with their bright lines and their more or less visible continuous light, can be explained in this way, we have no longer to deal with a very enigmatical nebulous matter showing in its incommensurable aggregations neither any clear condensation into centres of attraction *nor any relative motion of its different parts even in the line of sight* (Keeler: *Nature*, Dec. 27th, 1894). We can then comprehend also why nebulæ described by Herschel as easily resolvable, as, for instance, G.C. 4499, G.C. 4827, could show to Huggins a gaseous spectrum. Such clusters, when spectroscopically observed, lose almost entirely by spectral dispersion the white light of their small still visible stars, and show only clearly as a gaseous spectrum the light of their countless already invisible and extinguishing "new stars." It is clear, moreover, that if the explanation suggested above is made to depend a little upon my views as to the origin of new stars, that dependence is not at all necessary. New stars may be due to collisions of stars (Vogel), of stars and cosmical clouds (Seeliger), of a star and smaller bodies crossing its atmosphere (Belopolsky), of meteoritic swarms (Lockyer); they may be due to periastric tidal disturbances (Huggins), to gaseous eruptions on a single star (Sidgreaves), or to some other cause. My explanation demands nothing else than that in some clusters the production of new stars might be very abundant and much more abundant than in others. Since new stars, when small, may be easily overlooked, it is probable that even in our own cluster they are much more numerous than has been hitherto observed. Again, all other bright line bodies, such as, for instance, Beta Lyræ, Gamma Cassiopeiæ, the Wolf-Rayet stars, our sun, the red variables, and comets will eventually co-operate to cause the spectrum of a cluster to have a gaseous appearance.

I know very well that, since novæ show two superposed spectra, whose dark and bright lines are relatively displaced, this appearance has led to the hypothesis of a direct collision of two or more celestial bodies, or of one body and a cosmical cloud, the bodies strongly heated by the collision showing afterwards by the displacement of their lines their relative motion in the line of sight. But apart from the enormous amounts of the velocities so suggested—velocities of which no explanation is afforded, and which are almost inconceivable in their character—and apart also from many other difficulties that MM. Vogel and Seeliger and others have expounded in their discussions on this subject, (*a*) we are not obliged to see in the indicated displacement of lines a convincing proof of motion in the line of sight.

There are, indeed, countless experiments that have proved in our laboratories that, without any motion of the source of light, a displacement of lines can occur; firstly, by changes of pressure (*b*); secondly, by changes of temperature (*c*); thirdly, by changes of admixed matter (*d*); fourthly, by changes of chemical combination (*e*). Now, if one thing is absolutely certain in our knowledge of sun and stars, it is this, that in their superposed layers there must be great differences of pressure, temperature, admixed matter and chemical combinations. And it is therefore very strange that in general, in explaining the celestial spectra, all line displacements are simply interpreted as if all the experiments indicated above had never been made, and as if the only possible cause of such displacements was a hypothetical motion in the line of sight.

Our sun often presents dissymmetrical reversals having some analogy with those of the novæ. M. Deslandres has discovered that the dark reversal of the bright H and K lines does not always occupy the centre of these lines. Whatever may be the cause of such a dissymmetry, its occurrence in a single body proves that it does not in every case require the hypothesis of a collision of different bodies in order to explain it (*f*). M. Lockyer's photographs of the arc spectrum have shown, moreover, that even in the

(*a*) H. C. Vogel, *Astr. and A.*, December, 1893, January, 1894, February, 1894; "On the New Star in Auriga." H. Seeliger, *ibid.*, p. 142; "On the New Star in Auriga."

Fr. Sidgreaves, *Mem. of the R.A.S.*, 51, p. 34. W. H. Pickering, *Astr. and A.*, 94, p. 201.

"It may be also that the spectral lines are liable to be displaced by other causes than motion in the line of sight. The spectrum of the nova in Auriga is rather startling, if such velocity is the only admissible explanation of it." (W. H. Monck, *Publications of the Ast. Soc. of the Pacific*, VII. p. 38). If the sudden up-blazing of the novæ were due to heat evolved by some collision of stars, their afterwards rapid reduction of light would be inconceivable (Scheiner, *Spectr. d. Gestirne*, p 300; Lockyer: *The Meteoritic Hyp.* p. 326). How much easier that rapid reduction can be understood when, admitting that the temperature remains almost unchanged, the phenomenon is entirely due to the temporary dispersion of a dark veil in the outer layers of the star, which there necessarily recondenses again by loss of heat as soon as there no longer a sufficient heat is evolved by chemical combination. The rapid reduction of light being so explained, we have there (as well as in the red variables) a phenomenon of the same order as the darkening of our sun by even the smallest clouds in our sky.

(*b*) Zollner, *Ber. d. Sachs. Ges. d. Wiss*, 31st October, 1870, p. 233. Müller, *Pogg. Ann.* 150, p. 311.

Lockyer, *Phil. Trans.*, 74, p. 805. *Proc. R. S* 79, p. 428. Liveing and Dewar. *Proc. R. S.*, 28, p. 367. Schuster, *Nature*, 75, p. 148.

Ciamician, *Wiener Ber.*, 78, p. 886. Schuster, *Die spectralanalyse v. Roscoe*, 90, p. 148. Scheiner, *Spectralanalyse d. Gestirne*, p. 143.

(*c*) Roscoe, *Die Spectralanalyse* 1890, p. 148. *Proc. R. Soc.* 21, p. 282.

(*d*) Lockyer, *Chemistry of the Sun*, pp. 369-370. Vogel, *Pract. Spectr. Anal.* p. 248.

Mon. d. Ak. d. Wiss. (Mai, 1878). *Spectr. Anal. v. Roscoe*, 1890, fig. 63 (4, 5, 6)

Claes, *Wied. Ann.* 3, p. 389. Kundt., *ibid.* 4, pp. 34.

(*e*) Russell, *Phil. Trans.* 81, p. 887. *Proc. R. Soc.* 32, p. 258. *Die Spectralanalyse v. Roscoe*, 1890, pp. 163-173. Mitscherlich, *Ann. Phys. Chem.* 121, p. 3.

(*f*) Deslandres, *Comptes Rend.*, 29 Aout., 1894, p. 457.

arc spectrum the absorption line does not always occupy the exact centre of the bright band (*g*). Now, if already in the different layers of the voltaic arc the lines belonging to the same matter show such clear changes of refrangibility, how much greater changes can be expected in the different layers of stars, which differ so far more widely.

We have here to deal with a vastly more complicated piece of mechanism than has hitherto generally been supposed. Chemical and electrical luminescence, cold flames with discontinuous spectra, displacement of lines without any motion in the line of sight, are facts which can no longer be discarded. They must be taken into account. So we shall get more trustworthy results than by continuing to solve all spectral problems by the principles of Kirchhoff and Döppler only.

THE EXTERIOR NEBULOSITIES OF THE PLEIADES.

By Miss A. M. Clerke, *Authoress of "The System of the Stars" and "A Popular History of Astronomy during the Nineteenth Century," &c., &c.*

WHAT a powerful telescope is to a multitude of remote star-clusters, a common opera-glass is to the Pleiades. Its use just suffices to tranquillize their images, while leaving intact the visible evidence of their close association. A single glance embraces the entire brilliant group, and takes in the peculiarities of its configuration, which, once seen, are not easily forgotten. The scenic effect is splendid, and ought to be familiar. At the first instant, one is almost startled at the beauty and wonder of such an assemblage of lustrously white orbs, poised, as it were, in the breathless stillness of an apparition, and distributed with a semblance of express arrangement, very different from that of a casually collected crowd. Behind them, the sky, thus seen, appears intensely black; yet the "silver braid" of the poet's fancy is now perceived to have been an unconscious forecast of coming knowledge. The Pleiades are, in very fact, "tangled" and wreathed in cosmic material. Tempel's discovery, in 1859, of the great Maia nebula gave the first hint of this state of things. He intuitively apprehended its importance. That "breath-stain" (*Hauch*) on the vault of heaven would, he used to declare, perpetuate his name. And its significance, both in itself and as an earnest of further disclosures, is still very far from being exhausted.

The reproduction, in Knowledge for May, 1891, of Dr. Roberts's astonishing photograph of this cluster, gave our readers the opportunity of judging for themselves as to the nebulous relations of its component stars. They are now invited to look further afield. Between the Pleiades and the Milky Way to the north, the elder Herschel located one of those tarnished sky-areas which he alone among his contemporaries and immediate successors was capable of perceiving. "Diffused nebulosity," as he called it, evades, as a rule, direct observation, so that the experience recently gained of its considerable self-recording power is particularly welcome; all the more so that this kind of dim phosphorescence seems to denote the presence, not of mere vague outflows of tenuous matter, but of more or less definite constructions, modelled by the play of, to us, inscrutable forces. In obtaining pictures of them, telescopes are left nowhere by ordinary portrait lenses. Dr. Max Wolf has shown,* both practically and theoretically, that his two and a quarter inch aplanatic doublet is five times more effective for the chemical delineation of nebulæ than the Henry thirteen-inch photographic refractor, although thirty-two times its inferior in getting impressions of stars. With this unpretending instrument he obtained in 1890 indications of extensive nebulosities near, and plainly not unrelated to the Pleiades.† For the intervening space, although wide, was spanned by nebulous "bridges," survivals perhaps of an antique condition, if not the means of present communication.

In the course of his comet-searches, meanwhile, Prof. Barnard had become telescopically familiar with Herschel's "much-affected" region north of the Pleiades (Knowledge, January, 1892), and formed the project of letting his famous "Willard lens" have a good long look at it on the earliest available occasion. This was on December 6th, 1893, and the experiment was continued on the night but one following, giving a total exposure of more than ten hours. With what results can be seen by turning to our plate, in which an enlargement, made by Prof. Barnard himself from the central portion of his negative, is reproduced. Obliterated by its own brilliancy, the actual cluster, with its filmy domestic furniture, is merged in a featureless mass; but it is easy to discern several nebulous outflows from it through the dense throng of surrounding stars. The most conspicuous of these run eastward, one from the northern, the other from the southern side of the central mass; and an effusion to the south-west is likewise manifest.

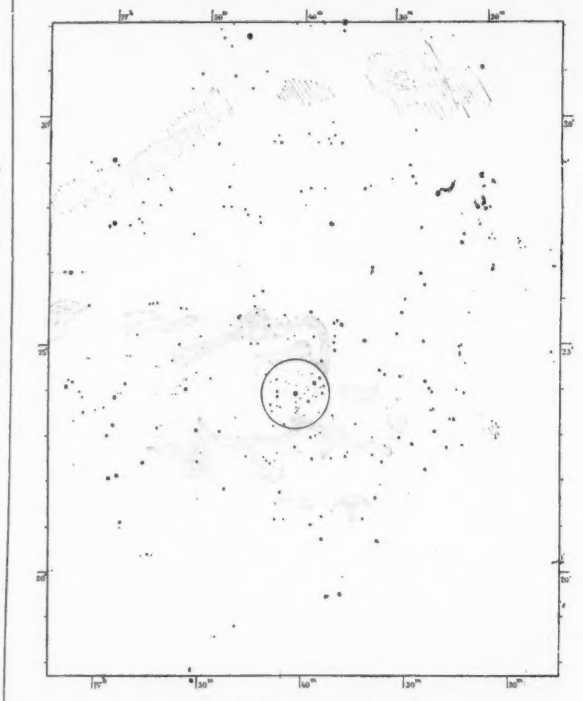


Fig. 1.—Key-Map to the Exterior Nebulosities of the Pleiades.

The picture, however, which should, for the purpose of comparison, be turned sideways with the north uppermost, is best elucidated by the accompanying sketch-map (Fig. 1), made by the artist from the original negative, with which it is co-extensive. It covers, in fact, about one hundred and fifty-eight square degrees, and reaches up to

(*g*) *Chem. of the Sun*, p. 221.

* *Sirius*, 1891, p. 106.

† *Astr. Nachrichten*, No. 3275.

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SOUTH.

WEST.

EAST.

NORTH

PHOTOGRAPH OF THE NEBULOSITIES SURROUNDING THE PLEIADES.

Taken by Mr. E. E. BARNARD, at the Lick Observatory, Mount Hamilton, California, on December 6th and 8th, 1893, with the Willard lens of 6 inches aperture and 31 inches focal length. Total exposure 10 hours 15 minutes. Scale, 1 mm.= 2′ of arc.

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Taken by Mr. E. E. Barnard, at the Lick Observatory, Mount Hamilton, California, on December 6th and 8th, 1893, with the Willard lens of 6 inches aperture and 31 inches focal length. Total exposure 10 hours 15 minutes. Scale, 1 mm.= 2′ of arc.

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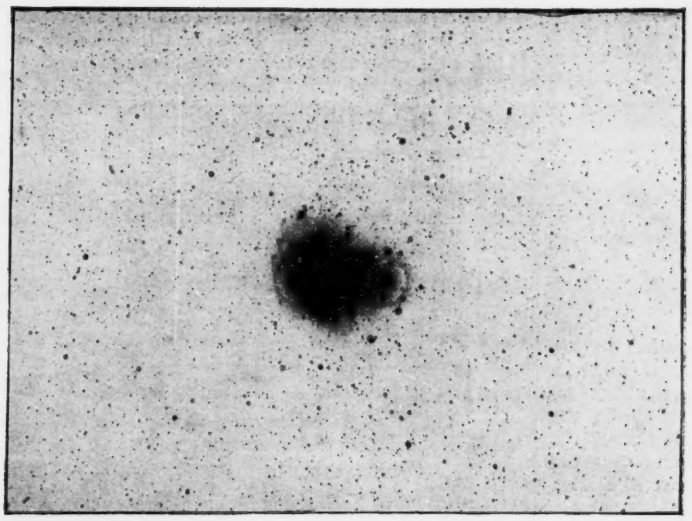
the left foot of Perseus. Yet the fragmentary nebulæ registered in this neighbourhood cannot, however vastly remote, be dissevered from the rest. The precise nature of their connection needs further investigation; but the conjecture seems plausible that, on the sensitive plates of the future, all will combine into a spiral structure not far inferior in dimensions to the stupendous coils involving a large majority of the Orion-brilliants.

The large, round, burnt-up surface on the plate is denoted on the map by a circle enclosing the star-group, with its now well-known appendages. Relatively to the entire span of the gigantic nebulous system half disclosed, half suggested in the new photograph, it is surprisingly small. Yet there beyond question lies the nucleus, and there possibly resides the dominating power of the grand exterior formation. That they are parts of a whole is most clearly indicated. One cannot fail to remark, however, that within the precincts of the cluster, individual nebulæ adhere, in the main, to individual stars; while outside of them, the relations are more generalized. Maia resembles a diamond clasp on a curving plume; Electra protrudes a luminous tentacle straight towards Alcyone; Merope, besides its sweeping gauze-train, has a close nebulous satellite, round and condensed, like a distant comet, as yet unprovided with perihelion-trappings. This singular couple, separated by a clear interval of barely ten seconds, was first expressly observed by Prof. Barnard, with the Lick thirty-six inch, in November, 1890; but was then proved to have been already photographed at Oxford and Lick. If for no other reason, it deserves attention for its illustrative bearing upon speculations regarding the origin of double stars. Our present purpose, however, is to point out that while the Pleiades nebulæ show a detailed connection with the members of the group, the new ones, to which Prof. Barnard introduces us, seem to depend upon the group as a whole. This large structural affinity is manifest in the single fact that the two chief nebular branches issue from the cluster at opposite ends of one of its diameters.

"At opposite ends of one of its diameters," we repeat; since the photograph we are engaged in considering intimates, or rather asserts, the shape of the central stellar collection to be roughly globular. Yet its components give no sign of condensation towards a centre. They are then, it may be presumed, scattered very sparsely throughout the congeries of attached nebulæ, the whole conceivably rotating with extreme slowness on a common axis. In this not impossible, though scarcely probable case, a statical equilibrium would prevail, and the stars should continue relatively fixed. And we recall that the measures hitherto executed upon them have afforded no proof of systemic circulation. It would, none the less, be the height of rashness to infer its absence on negative evidence collected during little more than half a century—a mere moment of cosmical time. The mechanism of clusters offers indeed a problem for the present insoluble—scarcely to be reached by so much as a conjecture.

Part of a photograph taken by Prof. Barnard in four hours, December 1st, 1893, is shown in Fig. 2. The halation rings, so curiously conspicuous in it, are, we need hardly say, a purely photographic effect, and each seems to be associated with several stars. It is an inverse representation. The stars are printed black on a white ground, as in the original negative, the object in view being to bring out more clearly the peculiarities of their distribution. Away to the north-west, on a part of the plate not included in the accompanying reproduction, a meteor has inscribed its "adsum" by means of a short, broken trail, indicating movement, so far as it deviated from the line of sight, towards the south-east. But the apparition was doubtless a mere flash, although a tolerably bright one, since it was registered in—at the most—one seven thousandth part of the time allotted to the stars.

S.



E. W.

N.

FIG. 2.—Photograph of the Pleiades, by E. E. Barnard. Exposure = 4h., December 1st, 1893. Scale, 1mm = 4′·5 of arc. In reproduction the photograph has been reversed, right and left.

Turning again to the plate, we perceive with amazement that the sky-vista, which after four hours of exposure lay comparatively open, became, in the course of ten, almost choked with star-discs. They exhibit no trace of condensation towards the cluster, or of any other kind of arrangement relative to it; and must be taken therefore to represent the contents of the backward-lying abyss. Clearly, then, the Pleiades are projected upon a stratum of small stars, to which probably belong the great majority of the two thousand three hundred and twenty-six mapped by the MM. Henry. It follows that we are still in the dark as regards the true nature of this wonderful aggregation. For its genuine members must be associated, indistinguishably, except through the effects of proper motion, with a multitude of fictitious Pleiades. Of these, half a dozen have been already expelled by Dr. Elkin's remeasurement, in 1885, of thirty-two stars determined by Bessel during the years 1829–1841, and the proportion of intruders may be assumed to increase enormously with descent to the lower ranks of brightness. But about twenty years must elapse before they can be surely identified. The cluster, as a whole, drifts nearly six seconds a century in a direction sensibly opposite to that of the sun's advance through space. Stars not belonging to it will, accordingly, be left behind; and when the lag amounts to two seconds,

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there will be little risk of error in recognizing it on carefully exposed and carefully measured negatives. This process of elimination may go very far, leaving a physical group scant in number comparatively to the optical group with which we are at present acquainted. Those among us will know the upshot who live to see the next return of Halley's comet.

One element of the motion of Alcyone and its companions might indeed before now have been ascertained; and, considering the special interest of the subject, it is rather surprising that the spectrographic method has not yet been applied to its investigation. Line-displacements, produced by the retreat from the cluster of the solar system, should at any rate be perceptible in the spectra of its components; and individual modifications of this general effect might also be brought to light. The research is one of great promise. Data derived from it, if of the order of accuracy now easily attainable, will be of crucial importance; and they will gratify, not prospective, but immediate curiosity. They will not be garnered only for the benefit of posterity. Let us hope that they may be promptly obtained.

ON THE EXTERIOR NEBULOSITIES OF THE PLEIADES.

By Prof. E. E. BARNARD.

IN the *Astronomische Nachrichten*, No. 3253, I have given an account of a long-exposure photograph of the Pleiades. A diagram drawing accompanies the article, which shows the positions of a number of faint nebulous masses and strips extending in all directions about the Pleiades, and apparently connected with the nebulosities of the cluster itself.

This picture was made with the six-inch Willard lens of the Lick Observatory on the nights of December 6th and 8th (the 7th was cloudy), 1893, the exposure being 10h. 15m.

It was my intention to repeat this exposure in the past winter with a greater duration, but the winter proved the most unfortunate for observation that we have yet had at Mount Hamilton, and nothing could be done while the Pleiades were in a favourable position.

I have, however, succeeded in making an enlargement from the negative of 1893, that shows the principal ones of these nebulosities quite nicely.

Some of the fainter streams and masses are lost in this enlargement, but enough remains to show clearly the nature of the nebulosities and their relation to the Pleiades.

Two irregular streams of nebulosity are shown in the picture, running towards the east. They flow from the north and south sides of the cluster, and run brokenly for three or four degrees easterly. These are the most prominent of the new nebulosities.

Looking carefully at the picture, it will be seen that the northern stream is double for a good part of its length, the northern portion being very faint.

To show these faint nebulosities it was necessary to sacrifice all the nebulosities of the immediate group along with the bright stars of the cluster.

This is of no importance, however, since they are all well known through previous photographs. The present picture is intended only to show the new nebulosities.

On this subject I have an interesting letter from Dr. H. C. Wilson, of the Goodsell Observatory, Northfield, Minnesota.

Speaking of these distant nebulosities about the Pleiades, Dr. Wilson says, June 26th, 1895:

"I have an eleven hour exposure on the Pleiades region taken on October 23rd, 24th, 26th, 1894, which shows most of the great nebula sketched by you from your photographs. It is so delicate that I did not see it until I made a positive which considerably increased the contrasts."

The small illustration is part of a duplicate negative of the Pleiades region.* This gives a good idea of the arrangement of the stars in that region of the sky, and their relation to the Pleiades.

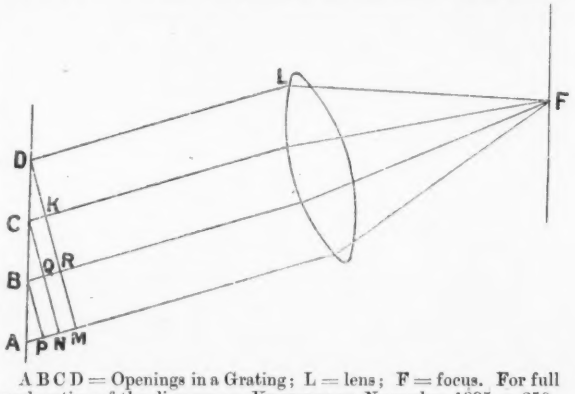
This picture was made 1893, December 1st, and was given four hours exposure (from 6.35 p.m. to 10.35 p.m.). In the north-west part of the entire plate a meteor trail is seen, directed nearly towards the Pleiades, but it does not extend into the part of the plate reproduced.

SPECTRUM ANALYSIS.—III.

By J. J. STEWART, B.A.Cantab., B.Sc.Lond.

THE application of the spectroscope to the determination of the chemical nature of a substance depends upon the peculiar nature of the spectrum given by incandescent gases, which was referred to in a previous article (KNOWLEDGE, No. 117, p. 150). This consists of one or more bright lines of definite colour separated by dark spaces, and the number and position of these lines is characteristic of the gas which gives out the light. Each element, when in the state of a glowing gas, possesses a spectrum which is peculiar to itself and differs from that of all other substances. The position of the bright lines in the spectrum of a given substance can be noted, and if bright lines occupying these positions occur in the spectrum of some compound which is under investigation, the observer knows that the element in question must be present in the compound. When the temperature of the flame is high the compound is probably dissociated or split up into its constituent elements, each of which gives its own spectrum with its characteristic lines indicating clearly the presence of the particular element.

That the presence of these lines shows distinctly that a certain element must be present follows from the fact that



A B C D = Openings in a Grating; L = lens; F = focus. For full explanation of the diagram *see* KNOWLEDGE, November, 1895, p. 250.

in no case has it yet been clearly shown that any of the lines of two elements coincide in position. They do not overlap, and when two lines in two different spectra occupy the same position, this indicates that there must be some element which is common to the two substances

* This plate has been accidentally reversed, right for left, in copying. This smaller photograph covers very nearly the same area as the larger. The scale of the larger is 1mm to 2′ of arc; of the smaller 1mm to 4′·5 of arc.

which give the spectra. If the same spectrometer is used throughout our observations, we can draw up maps of spectra very readily by noting the position of the observing telescope on the graduated scale of the instrument when a definite line is on the cross wires of the eye-piece.

In careful comparisons a still better and more certain method than comparing maps is to observe the two actual spectra at the same time, one being caused to occupy a position above the other. If the same lines occur in both the spectra they are seen at once to overlap, or some of the lines in the upper spectrum are continued in the lower. The upper spectrum may be that of a known element, the presence of which in the second substance is being tested. In order to cause one spectrum to fall above the other in this way, many spectroscopes are furnished with a small right-angled prism, which by means of internal reflection at one of its faces causes the spectrum from a neighbouring source of light to be thrown above that of the flame placed in front of the slit.

This method of analysis by means of observations on the spectra of flames containing substances in the form of incandescent gases gives a test of extraordinary delicacy for the presence of elementary substances. The method far surpasses those formerly used in chemical analysis. The presence of sodium in the ordinary air we breathe is shown quite clearly when we observe a colourless flame, like that of the Bunsen lamp, through a spectroscope. The yellow lines of the sodium spectrum shine out when the flame is burning quietly by itself, although the quantity of sodium present must be extremely small, coming as it does merely from the salt borne by the wind from the tossed up foam of the sea. In fact, the presence of the three millionth part of a milligramme, or the one hundred and eighty millionth of a grain of sodium, in a flame can be detected by spectroscopic observations. The usual occurrence of the yellow line in various spectra puzzled chemists for long, and some supposed it must be due to a substance universally present, such as water; but Prof. Swan showed its true source, and its practically constant occurrence may be put down to the fact that no part of our country is very distant from the sea. By means of spectrum analysis, many substances such as lithium, which were considered of comparatively rare occurrence, have been shown to be present in many mineral waters. Lithium itself has been found in vegetable structures and in the human body, in the blood and muscular tissue, and may play a formerly unsuspected part in the economy of nature.

Amongst the rarer elements, whose existence was unknown until they were detected by means of the spectroscope, are cæsium, rubidium, indium, thallium, and gallium. Cæsium and rubidium were discovered by Bunsen in 1860. Rubidium is named from two splendid deep red lines which are given by its vapour. Cæsium derives its name from the two characteristic blue lines of its spectrum. These two metals have since been found in the water of many mineral springs, and rubidium is widely diffused, being found in beetroot, in tobacco, and in coffee, tea and cocoa.

In spectroscopic observations on gases such as hydrogen and oxygen, electric discharges from the terminals of an induction coil are sent through a tube of the rarefied gas, which is thus caused to give out a luminous glow. In the case of metals which are volatilized with difficulty, the electric arc is made use of, the metals being exposed to the intense heat between the carbon points. The spectra of gases vary in many cases when the pressure to which the gas is subjected is changed.

It was observed by Wollaston, and afterwards by Fraunhofer, that when sunlight is drawn out into a spectrum by means of a prism, the broad band of colour obtained is not strictly continuous, but is traversed by dark lines, indicating the absence of rays of certain refrangibilities. This peculiarity was also found to exist in the spectra of many of the fixed stars. The reason of the appearance of these dark lines for long remained mysterious, and the mystery was rather increased than diminished when Fraunhofer observed that the bright double line produced by incandescent sodium vapour coincided in refrangibility and in position in the spectrum with the double dark line called D in the solar spectrum. A step towards the solution of the difficulty was made when Sir D. Brewster showed that analogous lines were produced when a jar of nitrous acid gas was interposed in the path of a ray of light. This experiment seemed to indicate that the dark lines were not due to the absence of certain rays from the light as it was originally given out by the sun, but were caused by the absorption of certain rays of definite refrangibility by vapours which the sunlight passed through before reaching the observer. Whether the vapours producing this absorption and cutting off of part of the rays were situated in the atmosphere of the sun or in that of the earth, remained unsettled until the question was finally cleared up by the experiments of Kirchhoff in Germany. The insight of Sir G. G. Stokes had previously suggested the true explanation, though this suggestion seems to have been unknown to Kirchhoff, whose experiments were carried out quite independently.

Kirchhoff found that when light from incandescent sodium passed through sodium vapour at a lower temperature, the characteristic yellow rays were absorbed by the vapour. Gases or vapours which are capable of giving out certain rays when they are sufficiently raised in temperature, are also capable of absorbing these same rays. This property is analogous to that which occurs in experiments on sound. A tuning-fork or stretched wire which can vibrate so as to give out a note of definite pitch when it is struck, can also absorb or take up this vibration from the surrounding air when a fork or wire giving the same note as itself is sounded near it. When a source of light of great intensity, such as the light from incandescent lime or that of the electric arc, is placed behind a sodium flame whose temperature is lower, it is found that the continuous spectrum formed by the light which has passed through the sodium vapour has a dark line in the place of the yellow line D which the sodium vapour itself gives out. The appearance is as if there was a narrow dark gap at the position of the D line in the spectrum which is otherwise continuous. In the case imagined, the dark line does not denote entire absence of these rays from the spectrum, but merely that the light at that part is much less intense than that from the surrounding portions, producing thus the effect of darkness in comparison with the rest of the spectral band. In fact, the light from the dark line is of the same intensity as that which would be given if the sodium flame was observed alone, the intense light behind it being removed. The sodium vapour absorbs those particular yellow rays which it can itself give out, the light reaching it being, after transmission, destitute of such; but the vapour, being itself incandescent, gives out on its own account rays occupying the same position as those which it absorbed and filtered out of the light reaching it. Thus the dark line is lit up only by light from the sodium flame, which being much less intense than that from the powerful electric arc, seems black in comparison. If a sodium flame sends light of the same intensity through that of another sodium flame, that is, if we take two flames of the

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same temperature, there will be no dark line produced. The absorption of the light will take place as before, but as the light given out by the second flame is of the same sort and of the same intensity, it simply takes the place of the absorbed light, and the result is that no dark line occurs. If light, forming a continuous spectrum, but coming from a source at a lower temperature than an interposed sodium flame, be observed with a spectroscope, the yellow D lines are seen as bright lines on a background formed by the continuous but less bright spectrum.

Kirchhoff concluded from his experiments that the dark D line in sunlight was caused by the presence of sodium vapour in the atmosphere of our luminary at a lower temperature than the source of light. This conclusion was strengthened when he observed dark lines coinciding with the bright lines given out by various metallic vapours, and in this way the presence of iron, nickel, calcium, magnesium and other metals was detected in the solar atmosphere. The lines C and F in the solar spectrum were proved to be due to hydrogen, and no fewer than four hundred and fifty of the solar dark lines have been identified with the bright lines given out by iron. On the other hand, the lines which would be produced by the absorption due to mercury, gold, aluminium, lead, tin, and some other elements are not found in the solar spectrum, and their absence seems to point to the conclusion that these elements are lacking in the sun's absorbent atmosphere.

MISTLETOE AND MISTLE THRUSH.

By Graham W. Murdoch.

THE mysteries which have gathered round the mistletoe plant, the *Viscum album* of botanists, have struck their roots deep in the romance of folk-lore, in the evolution of cults and superstitious ceremonial, far beyond even the deep woodland ritual of the Druid priest. Even the most learned of philologists of the present day are not agreed as to the origin of the word. It fills, too, no inconsiderable space in realms of poetry. Our great Elizabethan dramatists have employed it and its imaginary properties and parasitical ways to point their morals. Under its boughs, at the merry Christmastide, many a life's romance, many human comedies and even tragedies, have received their first meaningless or passionate note of inspiration. In this article we must not be tempted, beyond this casual allusion, into a consideration of the mistletoe in any of these fascinating fields of speculation. Our purpose is to point out certain purely scientific phenomena in connection with the plant and the mistle thrush (*Turdus viscivorus*), about which much controversy has been waged, and in connection with which considerable ignorance still prevails, even among botanists and ornithologists. For instance, in one of the standard German works on sylviculture ("The Waldschutz of Kauschinger," by Hermann Furst), the statement is made that the mistletoe plant "probably" owes its wide extension and reproduction to thrushes, which eagerly consume its berries, and "in cleansing their beaks from the sticky flesh of the fruit, leave a portion of it on the bark of the tree along with some of the seeds contained in it." That is not so, as we shall show, and the elements of science romance are interwoven with this very theory of seed propaganda and of specific *modus operandi*. Curiously enough, the ancient theory which found favour with Aristotle, Pliny, Ælian, Phile, and others, and which the poets followed blindly and enlarged upon in metaphor form, was rudely assailed by Lord Bacon in his "Sylva Sylvarum" (1635), and even more vigorously ridiculed by the very sceptical Sir Thomas Browne in his "Pseudoxia Epidemica" (1672), but is now established as true beyond the shadow of a doubt. The truth has been revealed by the labours of field naturalists and observant botanists working on the very inductive lines of reasoning that Lord Bacon is popularly credited with having "founded," and which undoubtedly were successfully employed by Sir Thomas Browne in exposing many "Vulgar Errors." Lord Bacon ventures upon reasons for discarding the ancient theory, which are altogether fallacious. The passage will be found on pages 139 to 142 of the edition referred to, the old spelling and punctuation and use of capital letters being followed.

"We finde no Super-plant that is a Formed Plant, but Misseltoe. They have an idle Tradition, that there is a Bird, called a Missel-Bird, that feedeth upon a Seed, which many times shee cannot digest, and so expeleth the whole with her Excrement which falling upon a Bough of a Tree, that hath some Rift, putteth forth the Misseltoe. But this is a Fable: For it is not probable, that Birds should feed upon that they cannot digest. But allow that yet it cannot be for other Reasons: For First it is found upon certaine Trees: And those Trees beare no such Fruit, as may allure that Bird to sit, and feed upon them. It may be that Bird feedeth upon the Misseltoe-Berries, and so is often found there: Which may have given occasion to the Tale, But that which maketh an End of the Question, is, that Misseltoe hath beene found to put forth under the Boughes, and not [onely] above the Boughes: So it cannot be any Thing that falleth upon the Bough. Misseltoe groweth chiefly upon Crab-Trees, Apple-Trees, sometimes upon Hasles; And rarely upon Oakes; The Misseltoe whereof is scounted verie Medicinall. It is ever greene, Winter and Summer; And beareth a White Glistering Berry: And it is a Plant, utterly differing from the Plant, upon which it groweth. Two things therefore may be certainly set down. First that Seeper-fetation must be by Abundance of Sap, in Bough that putteth it forth: Secondly, that that Sap must be such, as the Tree doth excerne, and cannot assimilate For else it would goe into a Bough; And besides, it seemeth to be more Fat and Unctuous, than the Ordinary Sap of the Tree, Both by the Berry which is Clammie; And by that it continueth greene, Winter and Summer which the Tree doth not."

The basis of Lord Bacon's objections to the ancient theory, and, as we shall show, correct theory, is that "it is not probable birds should feed upon that they cannot digest," the fact being that birds do feed on "that they cannot digest," but which is used as an aid to digestion. In the palmy days of falconry in this country, falconers knew this secret of nature, and more than one reference to it will be found in the dramas of the period. Thus Webster, for instance, in the great tragedy of *The White Devil*, Act III., Scene 1—

"Vittoria Corombona: Surely, my lords, this lawyer here hath swallowed
Some pothecaries' bills or proclamations,
And now the hard and undigestible words
Come up, like stones we used to give hawks for physic."

The fact is that it is a necessity for birds (the ostriches in particular) to swallow hard bodies, which remain in the pyloric region of the stomach and there play the part, as regards food, of masticatory organs. But as far as many seeds are concerned, it is notorious that they do pass through the organic system, not only of birds but of mammals, in an undigested form, and without their vital fructifying functions being destroyed. It is, of course, notoriously so with the seeds of the mistletoe as swallowed

and discharged by the mistle or, rather, mistletoe thrush. Sir Thomas Browne, in his "Pseudoxia Epidemica," follows Lord Bacon's sceptical rejection of the ancient theory of mistletoe plant propagation, and, indeed, goes more than one point further. He says: "Why if it ariseth from a seed if sown it will not grow again, Pliny affirmeth, and as by setting the berries thereof, we have in vain attempted its production: why if it cometh from seed that falleth upon the tree, *it groweth often downward* and puts forth *under the bough*, where seed *can neither fall nor yet remain*," &c. (page 106, edition 1672).

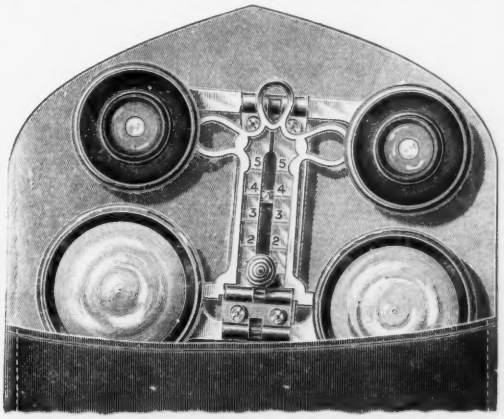
We have italicized those words of the sceptical doctor upon which he appears to have put most stress as destructive of the ancient theory, although, as a matter of fact, he was at one with Lord Bacon on the other points, and was equally astray. We have seen that a very distinguished German sylviculturist has propagated an entirely erroneous theory to account for the phenomenon that puzzled both Lord Bacon and Sir Thomas Browne. We must appeal to another great German authority to aid us in explaining the apparent mystery of the undergrowth characteristic of the mistletoe plant. The following passages will be found in Vol. I., pages 205-6, of the new English edition of "The History of Plants," by Anton Kerner von Marilaun, Professor of Botany in the University of Vienna:—

"The dissemination of the European mistletoe is effected, as in all the other Loranthaceæ, through the agency of birds—thrushes in particular—which feed upon the berries and deposit the undigested seeds with their excrement upon the branches of trees. That a preliminary passage through the alimentary canal of birds is essential to the germination of these seeds is no doubt a delusion, this assumption of former times being easily refuted by the fact that one can readily induce the seeds of berries, taken fresh from a tree and stuck into fissures in the bark of moderately suitable trees, to germinate; it is, however, true that in nature mistletoe seeds are dispersed exclusively by birds in the manner above mentioned. To this method of dissemination must be attributed the phenomenon, which, at first sight, is surprising, that mistletoe plants are rarely seated upon the upper surface of branches, but very frequently on the sides. For the dung of thrushes, which live upon mistletoe berries, is in the form of a semi-fluid, highly viscid mass, ductile like bird lime; and even when it is deposited upon the upper surface of slanting branches it immediately runs down the sides, sometimes extending in ropes twenty or thirty centimètres in length. Owing to the viscous mass thus following the law of gravity, the mistletoe seeds embedded in it are conveyed to the sides and even to the under surface of the bark, and there remain cemented. It may be a long time before a seed of the kind germinates, especially if it does not become attached until the autumn. The embryo is completely surrounded in the seed by reserve food. It is club-shaped and comparatively large, and is distinguished by the fact that the two oblong cotyledons, which are closely pressed together, but often somewhat wavy at the margins, are coloured dark green by chlorophyll, like the environing cellular mass filled with reserve materials. In the process of germination, the axis of the embryo, especially the part lying beneath the cotyledons, and passing into the hemispherical radicle, lengthens out, the white seed coat is pierced, and the radicle makes its appearance through the breach. Under all circumstances the emergent radicle is directed towards the bark of the branch to which the seed is adherent. This is the case even when the seed chances to stick with the radicle of the seedling pointing away from the branch, the whole axis of the embryo curving towards the surface of the bark in a very striking manner. Thus the radicle always reaches the bark, and having done so it becomes adpressed and cemented to its surface, spreads itself out in the form of a doughy mass, and so develops into a regular attachment disc. From its centre a slender process now grows into the bark of the host plant, piercing the latter and penetrating as far as the wood, but not growing into that tissue. This penetrating process has been termed a 'sinker,' and must be looked upon as a specially modified root."

In the language of the great German botanist, the whole mystery is cleared up, and the facts now made plain may even go some length in clearing up the philological difficulty about the origin of the words "mistletoe" and "mistle thrush." The theories of Dr. Prior, Bosworth, and others who traced the word to the old English mistiltan, "from 'mistl,' different, and 'tan,' a twig, being so unlike the tree it grows on," must be abandoned. It is possibly derived from the Scandinavian "mist," meaning dirt, or obscurity. But be that as it may, we have endeavoured to show that in the realm of pure science there are associations of mystery and romance quite as interesting as the associate ideas of Druidic ceremonial and cult, and almost as fascinating as the legendary significance of kissing under the mistletoe, with all its far-reaching or, it may be, quite ephemeral consequences. Then the bird itself has been the object of much study and an infinity of "fine writing." The habits are now well known, and have been frequently described. To our mind, its piercing but sweet strain of music, poured forth in the pauses of a wild February or March storm, possess the additional charm of mystery because, like the music of the robin or the wren, we cannot reconcile such voluntary bursts with the theory of sexual rivalry as the origin of avian song.

Some Recent Patents.

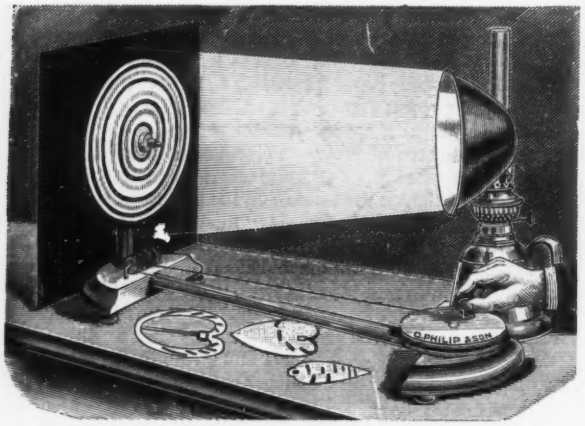
Messrs. R. & J. Beck are introducing a new patent called the Card-case Opera Glass. This ingenious invention consists of eye-pieces and object-glasses without connecting tubes. It folds up flat into a small space, and weighs only three and a half ounces. The



lenses are fairly good, and the glass will, no doubt, prove valuable to naturalists amongst others, as it can always be carried about without inconvenience. It would, however, be useless in wet weather, as the glasses have no protection.

J. B. W. Betts, of Plymouth. An improved apparatus for the production of bands of colour by the rotation of certain forms of any size, material or shape. This apparatus is intended for the same purpose as the spectrum top noticed in our columns some time ago. It consists of a wheel connected with an upright, on which designs (of different shapes and marked in different ways with black lines)

are fixed. By turning the wheel the design revolves. This action produces bands of colour in place of the black lines, and when the



motion is reversed the colours of the bands change. The chromoscope is being produced by Messrs. George Philip and Son, of Fleet Street, E.C.

THE FACE OF THE SKY FOR DECEMBER.

By Herbert Sadler, F.R.A.S.

SUNSPOTS and faculæ are slowly but surely decreasing in number and magnitude. Conveniently observable minima of Algol occur at 10h. 58m. P.M. on the 2nd; at 7h. 47m. P.M. on the 5th; at 9h. 29m. P.M. on the 25th; and at 6h. 18m. P.M. on the 28th. A maximum of Omicron (Mira) Ceti is due on the 9th.

Venus is a morning star, and is still a resplendent object in the eastern sky. On the 1st she rises at 3h. 17m. A.M., with a southern declination of 6° 59′, and an apparent diameter of $23\frac{1}{4}''$, $\frac{51}{100}$ths of the disc being illuminated. On the 7th she rises at 3h. 27m. A.M., with a southern declination of 9° 0′, and an apparent diameter of $22\frac{1}{2}''$, $\frac{54}{100}$ths of the disc being illuminated. On the 17th she rises at 3h. 47m. A.M., with a southern declination of 12° 24′, and an apparent diameter of $20\frac{1}{4}''$, $\frac{59}{100}$ths of the disc being illuminated. On the 24th she rises at 4h. 2m. A.M., with a southern declination of 14° 40′, and an apparent diameter of 19″, $\frac{61}{100}$ths of the disc being illuminated. On the 31st she rises at 4h. 19m. A.M., or three and three-quarter hours before the Sun, with a southern declination of 16° 47′, and an apparent diameter of 18·0″, $\frac{65}{100}$ths of the disc being illuminated. She is in conjunction with Saturn at 9h. A.M. on the 22nd, 33′ to the north. During the month she passes from Virgo, through part of Libra, to the confines of Scorpio.

Mercury, Mars, Saturn, and Uranus are all, for the observer's purposes, invisible.

Jupiter is an evening star. On the 1st he rises at 8h. 21m. P.M., with a northern declination of 18° 30′, and an apparent equatorial diameter of $42\frac{1}{2}''$, the phase amounting to $\frac{3}{10}''$. On the 6th he rises at 8h. P.M., with a northern declination of 18° 33′, and an apparent equatorial diameter of $43\frac{1}{4}''$. On the 16th he rises at 7h. 18m. P.M., with a northern declination of 18° 43′, and an apparent equatorial diameter of $44\frac{1}{4}''$. On the 26th he rises at 6h. 32m. P.M., or two and a half hours after sunset, with a northern declination of 18° 58′, and an apparent equatorial diameter of $45\frac{1}{4}''$. On the 31st he rises at 6h. 10m. P.M. with a northern declination of 19° 7′, and an apparent equatorial diameter of $45\frac{3}{4}''$. During the month he describes a short retrograde path in Cancer, being about $\frac{1}{2}$° N.E. of δ Cancri at the end of the month. The following phenomena of the satellites occur while the planet is more than 8° above and the Sun 8° below the horizon. On the 1st an occultation reappearance of the first satellite at 3h. 0m. A.M.; an eclipse disappearance of the second satellite at 4h. 18m. 42s. A.M.; a transit ingress of the first satellite at 9h. 58m. P.M., and a transit egress of its shadow at 11h. 12m. P.M.; an eclipse reappearance of the fourth satellite at 11h. 58m. 34s. P.M. On the 2nd a transit egress of the first satellite at 0h. 18m. A.M.; an occultation disappearance of the fourth satellite at 5h. 58m. A.M.; an occultation reappearance of the first satellite at 9h. 27m. P.M.; a transit ingress of the shadow of the second satellite at 10h. 36m. P.M. On the 3rd a transit ingress of the second satellite at 0h. 47m. A.M., a transit egress of its shadow at 1h. 39m. A.M., and a transit egress of the satellite at 3h. 42m. A.M. On the 4th an occultation reappearance of the second satellite at 10h. 39m. P.M. On the 6th a transit ingress of the shadow of the third satellite at 10h. 29m. P.M. On the 7th a transit egress of the shadow of the third satellite at 2h. 3m. A.M., a transit ingress of the satellite at 2h. 35m. A.M., a transit ingress of the shadow of the first satellite at 4h. 18m. A.M., a transit ingress of the satellite at 5h. 19m. A.M.; a transit egress of the third satellite at 6h. 15m. A.M.; a transit egress of the shadow of the first satellite at 6h. 37m. A.M. On the 8th an eclipse disappearance of the first satellite at 1h. 29m. 31s. A.M., its occultation reappearance at 4h. 48m. A.M.; an eclipse disappearance of the second satellite at 6h. 54m. 36s. A.M.; a transit ingress of the shadow of the first satellite at 10h. 46m. P.M., and of the satellite at 11h. 46m. P.M. On the 9th a transit egress of the shadow of the first satellite at 1h. 6m. A.M., of the satellite at 2h. 6m. A.M., and its occultation reappearance at 11h. 15m. A.M. On the 10th a transit ingress of the shadow of the second satellite at 1h. 10m. A.M., of the satellite at 3h. 9m. A.M., an egress of the shadow at 4h. 3m. A.M., a transit ingress of the shadow of the fourth satellite at 4h. 6m. A.M., a transit egress of the second satellite at 6h. 4m. A.M. On the 12th an occultation reappearance of the second satellite at 1h. 2m. A.M. On the 14th a transit ingress of the shadow of the third satellite at 2h. 26m. A.M., and its egress at 6h. 2m. A.M.; and a transit ingress of the satellite at 6h. 7m. A.M., a transit ingress of the shadow of the first satellite at 6h. 11m. A.M. On the 15th an eclipse disappearance of the first satellite at 3h. 22m. 51s. A.M.; an occultation reappearance of the first satellite at 6h. 35m. A.M. On the 16th a transit ingress of the shadow of the first satellite at 0h. 40m. A.M., of the satellite at 1h. 33m. A.M. an egress of the shadow at 3h. 0m. A.M., of the satellite at 3h. 53m. A.M., its eclipse disappearance at 9h. 51m. 11s. P.M. On the 17th an occultation reappearance of the first satellite at 1h. 1m. A.M., a transit ingress of the shadow of the second satellite at 3h. 43m. A.M., a transit ingress of the satellite at 5h. 28m. A.M., an egress of its shadow at 6h. 37m. A.M., a transit egress of the shadow of the first satellite at 9h. 28m. P.M., its egress at 10h. 20m. P.M.; an occultation reappearance of the third satellite at 11h. 24m. P.M. On the 18th an occultation disappearance of the fourth satellite at 9h. 33m. P.M., an eclipse disappearance of the second satellite at 10h. 47m. 57s. P.M. On the 19th an occultation reappearance of the fourth satellite at 2h. 16m. A.M., an occultation reappearance of the second satellite at 3h. 23m. A.M. On the 20th a transit egress of the second satellite at 9h. 33m. P.M. On the 21st a transit ingress of the shadow of the third satellite at 6h. 26m. A.M. On the 22nd an eclipse disappearance of the first satellite at 5h. 16m. 18s. A.M. On the 23rd a transit ingress of the shadow of the first satellite at 2h. 34m. A.M., of the satellite at 3h. 19m. A.M.; an egress of the shadow at

4h. 53m. P.M., of the satellite at 5h. 39m. P.M., its eclipse disappearance at 11h. 44m. 39s. P.M. On the 24th an occultation reappearance of the first satellite at 2h. 47m. A.M., a transit ingress of the shadow of the second satellite at 6h. 18m. A.M., an eclipse disappearance of the third satellite at 8h. 20m. 15s. P.M.; a transit ingress of the shadow of the first satellite at 9h. 2m. P.M., of the satellite at 9h. 45m. P.M., a transit egress of its shadow at 11h. 22m. P.M. On the 25th a transit egress of the first satellite at 0h. 5m. A.M., an occultation reappearance of the third satellite at 2h. 49m. A.M., an occultation reappearance of the first satellite at 9h. 13m. P.M. On the 26th an eclipse disappearance of the second satellite at 1h. 23m. 45s. A.M., and its occultation reappearance at 5h. 42m. A.M.; a transit ingress of the shadow of the fourth satellite at 10h. 4m. P.M. On the 27th a transit egress of the shadow of the fourth satellite at 2h. 33m. A.M., and an ingress of the satellite at 4h. 19m. A.M.; a transit ingress of the shadow of the second satellite at 7h. 35m. P.M., of the satellite at 8h. 54m. P.M., the egress of the shadow at 10h. 29m. P.M., of the satellite at 11h. 50m. P.M. On the 29th an eclipse disappearance of the first satellite at 7h. 9m. 52s. A.M. On the 30th a transit ingress of the shadow of the first satellite at 4h. 28m. A.M., of the satellite at 5h. 4m. A.M.; the egress of the shadow at 6h. 47m. A.M. On the 31st an eclipse disappearance of the first satellite at 1h. 38m. 15s. A.M., its occultation reappearance at 4h. 31m. A.M., a transit ingress of its shadow at 10h. 56m. P.M., of the satellite at 11h. 30m. P.M.

Neptune is an evening star, and is well situated for observation. He rises on the 1st at 4h. 20m. P.M., with a northern declination of 21° 19′, and an apparent diameter of 2·7″. On the 31st he rises at 2h. 15m. P.M., with a northern declination of 21° 15′. On the 16th he is 17½′ south of 105 Tauri. A map of the stars near his path will be found in the *English Mechanic* for August 16th.

The Moon is full at 6h. 38m. A.M. on the 2nd; enters her last quarter at 7h. 9m. A.M. on the 9th; is new at 6h. 30m. A.M. on the 16th; enters her first quarter at 5h. 21m. A.M. on the 24th; and is full at 8h. 31m. P.M. on the 31st. She is in perigee at 5h. P.M. on the 9th (distance from the earth 230,130 miles); and in apogee at 8h. A.M. on the 23rd (distance from the earth 251,260 miles).

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

Communications for this column should be addressed to C. D. LOCOCK, Burwash, Sussex, and posted on or before the 12th of each month.

Solutions of November Problems.

No. 1.—(T. A. Brock.)

1.—B to Bsq, and mates next move.

CORRECT SOLUTIONS received from Crossgar, G. A. F., W. Willby, A. H. Walker, W. O. Brigstocke, A. Norseman, E. W. Brook and Alpha.

An unusually large number of incorrect solutions to this problem have been sent in, as will appear below.

No. 2.—(A. C. Challenger.)

Key-move.—1. R × P.

If 1. . . . K to K3 or Q3, 2. R to R5.
1. . . . K to B3, 2. R to B7ch.
1. . . . Anything else, 2. R to B5.
Dual after 1. . . . K to K4 by 2. R to B5ch, or 2. R to Q7.

CORRECT SOLUTIONS received from L. Bourne, W. Willby, G. A. F., A. Norseman, E. W. Brook.

E. J. Wood and *W. W. Strickland.*—If 1. Q to QB5ch, B × K.

L. Bourne.—If 1. B to Q3, P to B4.

M. Wiedhofft.—If 1. B × P, B to Kt6. In No. 2, if Q × Pch, K to B4 (best).

G. C. Beazley and *J. Lamond.*—If 1. Kt × B, Kt moves.

W. O. Brigstocke.—The key-move is correct, but there are other defences to the threat besides R × B and B to Kt6; *e.g.*, 1. . . . P to B3 (which allows the Queen to cover), 1. . . . R × P, 1. . . . Q to B3ch, and 1. . . . Q to Q3 (a particularly fine variation).

A. Norseman.—Quite right; in fact, R4 was a misprint for R5.

A. G. Fellows.—Many thanks; it appears below. Sorry to say we know of no four-move tourneys at present. They are, of course, more common in Germany and Austria than in England. No communication on the other matter referred to has yet reached us.

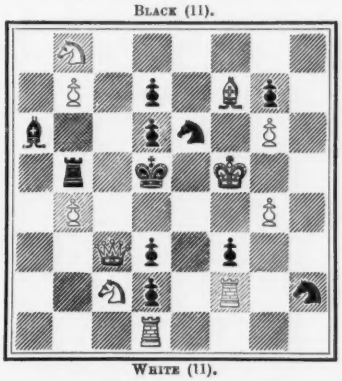
ERRATUM (November number).—Remark on Mr. Blakemore's problem: for "Pawn at QR4," read "Pawn at QR5."

PROBLEMS.

No. 1.

By A. C. CHALLENGER.

BLACK (11).



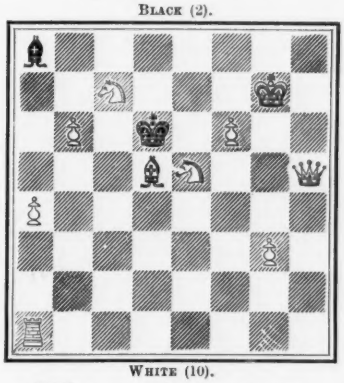
WHITE (11).

White compels Black to mate in two moves.

No. 2.

By A. G. FELLOWS.

BLACK (2).



WHITE (10).

White mates in three moves.

Chess Sparks. Collected and arranged by J. H. Ellis. (Longmans, Green & Co.) 4s. 6d. This attractively bound volume is a collection of four hundred games of a lively character and limited to twenty moves each. From the nature of the conditions it is evident that most of the brilliancies which occur have their origin in mistakes in the openings. Much, therefore, may be learnt in the way of recognizing and avoiding such errors by a study of these games. Many of the games are not those of recognized experts, in illustration of one of the mottoes of the book: "Little sticks kindle a fire; great sticks put it out." Nevertheless, we should hardly have called Mr. E. Lasker a "great stick." Space might well have been found for more than one game to illustrate his winning style. The compiler includes one game of his own. This we think his weaker opponent should have won without difficulty on the thirteenth move.

The book concludes with a chronicle of chess matches and tournaments played since the year 1824, and an index of the players of these "Chess Sparks."

CHESS INTELLIGENCE.

It is stated that the great quadrangular (or quintangular) tournament will begin at St. Petersburg about December 8th. The four players certain are Lasker, Pillsbury, Steinitz, and Tschigorin. Dr. Tarrasch cannot find time to play, and it is rumoured that his place will be given to E. Schiffers, who, though next to the five leading prize winners in the recent Hastings tournament, cannot be considered as a player of quite the same class. If this be so, his inclusion in the tournament would quite spoil it as a championship test; for his opponents, thinking that they ought to beat him, would not be content to draw games which should naturally be drawn, and in playing to win would not be unlikely to lose. If drawn games were replayed, as in the great London tournament, this element of risk would be eliminated; but this is not likely to be a condition in the present tournament.

Negotiations are in progress for a representative match by cable between England and America. There will be eight or ten players a side, and the match will not take place till after Mr. Pillsbury's return to America, so that he may be included in the American team.

The fifth Amateur Chess Tournament, in connection with the Craigside Hydro, Llandudno, will commence on December 31st. Besides the open competition for the challenge cup and the usual handicap, there will be a ladies' handicap and a tournament to decide the championship of North Wales. This latter event will take place a week later, and is confined to *bonâ fide* residents in North Wales. Entries for the other events close on December 30th, and should be sent before then to Mr. A. Firth, Bryn-y-bia, Llandudno.

Messrs. Lipschütz and Showalter, the two best players in America after Steinitz and Pillsbury, are now engaged in a match. The present score is Lipschütz 2, Showalter 1, drawn 1.

We append another game played in the Hastings tourney. Herr Marco was rather fortunate in escaping with a draw.

"Queen's Gambit Declined."

WHITE. Pillsbury.	BLACK. Marco.
1. P to Q4	1. P to Q4
2. P to QB4	2. P to K3
3. Kt to QB3	3. Kt to KB3
4. Kt to B3	4. B to K2
5. B to B4	5. Castles
6. R to Bsq	6. P to QB3
7. P to K3	7. P to QKt3
8. B to Q3	8. B to Kt2
9. Castles	9. QKt to Q2
10. P to K4	10. P × KP
11. Kt × P	11. Kt × Kt
12. B × Kt	12. Kt to B3
13. B to Ktsq	13. P to B4
14. P × P	14. Q × Q
15. KR × Q	15. B × P
16. P to QR3	16. KR to Qsq
17. P to QKt4	17. B to K2
18. Kt to Q4	18. Kt to Ksq
19. B to R2	19. P to QR4
20. P to B5	20. RP × P
21. P to B6	21. QB to Bsq
22. P to B7	22. R to Q2
23. Kt to B6	23. B to B3
24. Kt × P	24. R × Rch
25. R × R	25. B to Kt2
26. R to Q7	26. K to Bsq
27. B to B4	27. B to K2
28. P to R3	28. R to Bsq
29. B to R6	29. B × B
30. Kt × B	30. Kt to B3
31. R to Q3	31. Kt to Q7
32. B to K3	32. K to Ksq.
Draw.	

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